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A Handbook for Quick Cost Estimates

A Method for Developing Quick Approximate Estimates of Costs for
Generic Actions for Nuclear Power Plants

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Prepared for
U.S. Nuclear Regulatory
Commission

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A HANDBOOK FOR QUICK COST ESTIMATES

A Method for Developing Quick Approximate Estimates of Costs for Generic Actions for Nuclear Power Plants

ABSTRACT

This document is a supplement to *A Handbook for Cost Estimating* (NUREG/CR-3971) and provides specific guidance for developing "quick" approximate estimates of the cost of implementing generic regulatory requirements for nuclear power plants. A method is presented for relating the known construction costs for new nuclear power plants (as contained in the Energy Economic Data Base) to the cost of performing similar work, on a back-fit basis, at existing plants. Cost factors are presented to account for variations in such important cost areas as construction labor productivity, engineering and quality assurance, replacement energy, reworking of existing features, and regional variations in the cost of materials and labor. Other cost categories addressed in this handbook include those for changes in plant operating personnel and plant documents, licensee costs, NRC costs, and costs for other government agencies. Data sheets, worksheets, and appropriate cost algorithms are included to guide the user through preparation of rough estimates. A sample estimate is prepared using the method and the estimating tools provided.

1 INTRODUCTION AND SUMMARY

1.1 BACKGROUND

The Nuclear Regulatory Commission (NRC) has established the practice of performing regulatory analyses, including analyses of the costs and the benefits of resolving generic safety issues and of proposed new or revised generic requirements. To assist the NRC in establishing a consistent and methodical approach to performing such cost estimates, *A Handbook for Cost Estimating* (NUREG/CR-3971)¹ was prepared and published in the fall of 1984. That first handbook provides guidance on (1) identifying all potentially significant costs associated with the implementation of a generic requirement, (2) organizing and structuring a cost estimate, (3) using existing cost data, and (4) evaluating costs on a consistent basis to arrive at a total present worth of the lifetime cost for all affected plants. That first handbook was not intended as an all-inclusive resource book on preparing such estimates. For example, the handbook contains little actual cost data or other quantitative information from which cost estimates can be prepared. Rather, it was intended to be a how-to-do-it guide for the user on what to look for and how to prepare a cost estimate. That first handbook does not address the need for guidance in preparing quick, approximate estimates.

This handbook, therefore, is intended as a stand-alone companion to the first handbook by providing an alternative approach to cost estimating, specifically to address the need for a method to develop "quick" approximate estimates of generic requirements. Relevant cost data, worksheets, and other resource material are included to help the user in preparing such estimates. This handbook is not a refinement of the original handbook, but rather addresses a need not covered in the earlier work. This handbook does not rely on the user having mastered the methods and analytical tools presented in the first handbook (although the user will find this handbook easier to follow and use if he has a working knowledge of the material presented in the original handbook).

The user of this handbook is cautioned that this is not a cookbook to be followed blindly. The methods, rules of thumb, cost data, etc., presented here, are tools to assist the user in preparing a realistic estimate of the major costs associated with implementing NRC requirements, but should not be used as a substitute for sound judgment, research, and insight in evaluating requirements case-by-case. The cost categories dealt with in this handbook address the areas that most often dominate the cost of implementing generic requirements. The cost factors and rules of thumb presented here cover those cost elements found most often to be important in estimating these costs. However, the user should recognize that each requirement is unique and has its own specific problems, some of which may not be specifically dealt with in this handbook.

1.2 PURPOSE AND SCOPE

The primary purpose of this handbook is to provide a separate, stand-alone document that presents methods and information for the preparation of quick, order-of-magnitude estimates. This handbook should be suitable for rough "zeroing-in" estimates that can usually be prepared in not more than about one man-week -- even for major, complex generic regulatory actions -- and correspondingly shorter times for lesser and simpler actions. The handbook addresses all of the elements needed to prepare the estimates, including:

- Estimating methods.
- Current cost data, rules of thumb, cost factors, and guidance to sources of data in selected areas where such information is likely to be needed and where suitable information exists or where information in a useful form can be developed.
- Worksheets and other format guidance for optional use in presenting the information on which the estimates are based.
- An example of the use of this handbook in preparing quick estimates.

This handbook could also be helpful in preparing more precise estimates, if the technical details and cost data on implementation of the requirement are known to the desired level of precision. These more detailed estimates will take correspondingly longer to prepare.

1.3 APPROACH

The general approach to cost estimating in this handbook can be described in terms of four major activities to be performed by the cost analyst. These are:

- Identifying the plants that are affected by a requirement, choosing reference plants to be evaluated, and defining the technical resolution of the generic requirement for each reference plant.
- Selecting analogous structures, systems, etc., from the existing cost data base that best match the technical resolution for the reference plant being evaluated.
- Evaluating each of the major cost categories for the reference plant, using the data base costs and appropriate cost factors, rules of thumb, and other tools provided in this handbook, together with information from other sources as required.
- Distributing the reference plant costs over all affected plants and aggregating all of the plants' costs to arrive at the estimated total lifetime, present-worth cost.

As a result of the research conducted in the preparation of the original cost estimating handbook, eight major cost categories have been identified into which all of the major costs associated with the implementation of a generic regulatory requirement can usually be grouped. These eight categories, ranked in descending order of their expected significance, are:

1. Replacement energy cost.
2. Cost of changes to plant structures.
3. Cost of changes to plant systems and hardware.
4. Engineering, design, and quality assurance (QA) costs.
5. Cost of changes in plant personnel and/or their qualifications and in plant documents.
6. Utility licensing and administration costs.

7. NRC costs.

8. Other government costs.

These cost categories, when present, will tend to dominate the overall direct costs for most regulatory analyses, typically in the listed order of significance. The user should be sensitive to those cases when this is not valid. Many of the components of these categories have been addressed elsewhere by the Cost Analysis Group (CAG) of the NRC Office of Resource Management as a part of their Generic Cost Estimation Program. In this handbook, we will rely on information from many of these detailed generic cost estimates for the development of overall quick estimates associated with proposed regulatory changes. The approach here is to use gross representations of the more detailed results available in these CAG analyses. Estimates such as these would be generally suited for the prioritization of generic issues and multiplant actions.

The several chapters of this handbook deal with these cost categories individually and provide the NRC analyst with the methods, cost data, cost factors, and caveats that can be used to quickly estimate the rough cost of each category for the plant(s) affected by the generic requirement. Numerical examples are used where appropriate to illustrate the required calculations. Data sheets and worksheets are provided for each cost category to present concisely both the information needed to prepare the cost estimate and the algorithms to be used for the cost calculations. The completed worksheets also allow full documentation of the estimating process for the record.

Alternatively, if greater precision is deemed necessary, or if the specific cost component is controversial and dominates the overall cost assessment, the reader should rely on the more detailed results available from the underlying CAG-sponsored study. For example, in this handbook, estimates for replacement energy cost are differentiated by plant and by reactor type (boiling water reactor [BWR] vs. pressurized water reactor [PWR]) and by regional location on an average annual cost basis, whereas the CAG-sponsored study from which these estimates were derived contains seasonally adjusted estimates for each of the 108 nuclear units scheduled to be operational by summer 1986.

The CAG generic cost estimates incorporated in this handbook in a condensed format include:

- Replacement energy costs.
- Shutdown and startup costs.
- Labor productivity factor adjustments.
- Engineering and QA cost factors.
- Costs of revising technical specifications.

Each of these CAG generic cost estimates is supported by an extensive analysis (not included here) that provides the detailed results, derivation, uses, and limitations of

the specific cost component. At the point where each of these cost estimates is incorporated into this handbook, the reader is referred to the appropriate primary reference. In addition, the CAG is compiling a catalog titled *Generic Cost Estimates — Abstracts from Generic Studies for Use in Preparing Regulatory Impact Analyses*, which is mentioned throughout the handbook. This catalog will contain abstracts on all generic cost estimates available through the CAG. The references should be relied upon to ensure that estimates are current and are being applied correctly.

This handbook provides the tools for estimating the costs in the eight categories for the reference plant being evaluated. As a general guideline in evaluating the pertinent cost categories for the reference plant, the analyst should begin by first estimating costs for the category of greatest significance and then proceeding in order toward the category of least significance. When the estimate for a particular cost category is less than 10% significant compared to that for the least of the previously estimated categories, the remaining categories are likely to be insignificant to the overall estimate. Therefore, subject to confirmation that these items are indeed insignificant for the requirement being estimated, the remaining categories may not require detailed evaluation.

The final chapter provides an example of the use of this handbook for estimating the cost of providing a technical support center (TSC) for all commercial LWR plants. All appropriate data sheets and worksheets are completed for this example. The results of this example estimate are compared with the results obtained using the more detailed approach presented in the handbook and with the results of a study of actual costs associated with adding a TSC to several existing plants. The reference plant estimate of \$3.0 million calculated with the methods in this handbook falls well within the range of actual costs for the TSCs (\$0.8-\$4.0 million) and is 25% below the upper end of this range.

2 PREREQUISITES TO COST ESTIMATING

Three major prerequisites must be fulfilled before any meaningful cost estimate can be developed for a generic requirement: (1) defining the nature of the requirement as fully as possible, (2) identifying all of the plants affected by the requirement and grouping these plants according to their common resolution, and (3) defining the technical resolution for a reference plant that is selected to represent each group of affected plants. The importance of completing each of these prerequisites accurately and in sufficient detail cannot be stressed too strongly. The validity and credibility of the cost estimate will depend on the quality and depth of the technical information developed in these prerequisite activities. General guidance will be provided here for dealing with each of these activities. Additional guidance can be found in the handbook.

2.1 DEFINING THE REQUIREMENT

The logical first task in developing a technical resolution for a particular generic requirement is to analyze the provisions of the requirement itself. What type(s) of plants will likely be affected by the requirement? Will the requirement necessitate physical changes to the plants? What degree of urgency is likely to be attached to the implementation of the requirement? It is important to address these types of questions about the nature of the requirement in as detailed a manner as possible. The more precisely the provisions of the requirement can be defined, the more precisely the technical resolution can be developed and the more accurate will be the cost estimate. To assist the user in analyzing the provisions of the requirement, Data Sheet 2.1 has been prepared to highlight the provisions of the requirement that are likely to be important in developing a technical resolution. The user is cautioned that this data sheet may not cover all of the important provisions of all requirements and therefore should only be used as a guide to the type of information of importance.

2.2 IDENTIFYING AFFECTED PLANTS

Based on the analysis of the generic requirement conducted in the preceding section, the user must next identify all plants that will be affected by the requirement. Along with identifying the plants by name when necessary, certain technical and descriptive information about each plant will be helpful in grouping these plants according to the characteristics that will likely lead to a common resolution of the requirement for all plants in the group. In addition, information such as location, net capacity, plant status, etc., will be necessary to evaluate certain aspects of plant cost. Data Sheet 2.2 will assist the user in identifying the type of information that may be useful in characterizing each of the affected plants. This data sheet identifies certain characteristics that are essential to define for all plants, as well as examples of technical features that could be essential, depending on the nature of the requirement being evaluated. Appendix B contains a current listing (June 1985) of all U.S. commercial nuclear plants in operation or under construction.

DATA SHEET 2.1 NRC Generic Requirement

Requirement Name:

Current Status of Requirement

(generic safety issue, fully developed, etc.):

Ultimate Form Anticipated

(Reg. Guide, 10 CFR 50 change, MPA, etc.):

Provisions:

Categories of plants affected

(PWR, BWR, NSSS supplier, operating, under construction, etc.):

Physical plant changes:

Technical analyses:

Plant staff changes:

Time frame for implementation (immediate shutdown required,
long-term implementation, etc.):

DATA SHEET 2.2 Specific Plant Characteristics

Essential Characteristics

Plant Name:

Utility:

Location:

Type:

Net Capacity (kW_e):

NSS Supplier:

Architect-Engineer:

Status (% Complete):

Technical Features (typical)

Containment Type:

Ultimate Heat Sink:

Reference Plant Grouping:

The information compiled in the plant characteristics data sheet will be used to group the plants according to those features that will allow a common resolution of the provisions of the requirement for all plants within the group. Considerable care and thought should be given to the process of grouping the plants to minimize the number of groups for which cost estimates must be made while, at the same time, ensuring that the common resolution for each group is technically sound and reasonably cost-effective. It is highly probable that for generic requirements affecting a variety of plant types, more than one and perhaps several groups of plants will need to be identified.

The final step in identifying and characterizing the affected plants is to choose a reference plant from each group of plants for which a technical resolution will be developed and a cost estimate for implementing the resolution will be prepared. The cost estimate prepared for the reference plant will be assumed to represent all plants in that group. The credibility of the overall cost estimate will be determined in large part by the selection of the reference plant and whether the reference plant truly represents a reasonable resolution for all plants in the group. For this reason, it is important not to force plants into groups where a common technical resolution can be challenged. It is better to evaluate two or three additional reference plants to retain a high degree of credibility. Selection of the appropriate feature(s) around which the plants are grouped and the reference plant is selected is heavily dependent on the nature of the requirement. For example, a requirement that could result in a significant change to the containment suggests that the plants be grouped by type of containment as one important characteristic. Similarly, a requirement dealing with station blackout suggests that the provisions for supplying station backup power is an important characteristic in grouping the affected plants.

2.3 REFERENCE PLANT RESOLUTION

For each of the reference plants selected for evaluation in Sec. 2.2, a resolution must be developed to describe in as much detail as possible how the provisions of the requirement will be satisfied for the reference plant and what changes to the plant will be necessary. To aid in identifying areas to be addressed in describing the plant changes due to the requirement, we will use the eight major cost categories identified in Sec. 1.3.

2.3.1 Replacement Energy

The type of technical information needed to evaluate the replacement energy costs associated with the implementation of a generic requirement falls into four areas of consideration: (1) to what extent will the plant be out of commercial service while implementing the requirement, (2) to what extent will the plant be required to operate at reduced power, (3) to what extent will the plant capacity factor be affected by the requirement, and (4) to what extent will the net electrical busbar output of the plant be affected. Evaluating the cost effect of plant outage requires knowledge of the duration of the outage or of the period that the plant may be at reduced power to accomplish the changes. Judgment needs to be made as to whether the requirement will necessitate a forced outage of the plant, whether the changes can be accomplished as part of a

scheduled outage, or whether it will prolong a scheduled outage and by how long. Consideration should be given as to where plant modifications will be made. Major activities in the containment and service building will tend to affect scheduled outages much more so than in other areas of the plant.

Physical plant changes or changes to the operating technical specifications (operating units) for the plant can affect the capacity factor of the plant either negatively or positively. Where appropriate for the requirement being evaluated, an assessment of the effect of the requirement on plant capacity factor should be made.

The addition or deletion of major electricity-consuming equipment at the plant can have a significant effect on the net commercial output of the plant and therefore on replacement energy cost. For example, the addition of 1 MW_e of electrical load could reduce the annual output of a typical nuclear plant by about 6 million kWh, or by 180 million kWh over the 30-year life of the plant. The replacement energy cost for this lost output, calculated in present-worth dollars by the method shown on Worksheet 3.1, is \$8.2 million, based on a discount rate (D) of 10% and a replacement energy charge rate (R) of 10¢/kWh. Where appropriate, the change in the net commercial output of the plant should be estimated. This can have either a negative or positive effect, depending on whether the loads are added or removed as a result of the requirement.

2.3.2 Changes to Plant Structures

The effects of a regulatory requirement on the various plant structures will generally be felt in one of three ways: (1) requiring greater utilization of existing structures by using up space for new equipment or structural components, (2) requiring that existing structures be modified to house new equipment or structural components, and (3) requiring that new structures be built to house new equipment. To assess the extent to which the reference plant structures will be affected by a requirement, it is important to understand what physical changes to the plant will be required. Conceptual designs for new or modified hardware are required. Seismic requirements and nuclear safety classes for equipment should be determined. New equipment or equipment modifications should be sized and located within the existing plant layout to determine the utilization of existing structures, modification requirements for existing structures, and/or requirements for new structures. Conceptual designs for building modifications and new buildings must be developed. These designs or specifications should include -- at a minimum -- overall building size, building structural requirements and composition, seismic requirements, building service requirements, and special features.

2.3.3 Changes to Plant Systems and Hardware

The addition of new systems and/or other hardware is perhaps the most common type of change caused by a generic regulatory requirement. Systems modifications can range from the installation of a complete new facility such as the Technical Support Center (a TMI-related requirement) down to the addition of a single component in a system or subsystem. An important prerequisite to estimating the cost of hardware changes is development of the conceptual design for the overall change, including -- at a

minimum -- a rudimentary process flow diagram, technical specifications for major components, estimates of major equipment size, determination of nuclear safety class, selection of base materials, a rough layout of the equipment in the appropriate structures, identification of major interferences with existing equipment, and a preliminary schedule for the major tasks. This information will be used to identify analogous systems and/or equipment from an existing data base of technical and cost data for nuclear equipment. Also, this information is needed to determine the effects on the existing plant structures or the need for new structures.

2.3.4 Engineering, Design, and Quality Assurance

Engineering, design, and QA costs addressed in the cost estimate include preliminary and detailed design work for the systems and structures, plus special engineering analyses such as seismic analysis, pipe whip analysis, etc. that may be required. The routine engineering and design work that would be performed on the system and structure will be estimated from the cost data base as a percentage of the system's or structure's direct cost. The analyst should identify special engineering or design activities (such as those cited above) for which additional costs should be estimated. In defining these special activities, estimates of engineering hours, computer charges, etc. are important quantities. The routine QA activities that would be performed on the systems and structures will also be estimated as a percentage of the system's or structure's direct cost.

2.3.5 Changes in Plant Personnel and Documents

Permanent changes to the numbers, training, or qualifications of plant personnel as a result of the requirement must be identified. Plant personnel changes should be identified and categorized as operating, supervisory, maintenance, or technical support staff. If more detailed information on the nature of personnel changes is available, it may be helpful in estimating their costs. Technical support staff could include health physicists or engineers and operators could include reactor plant, auxiliary, and/or turbine plant operators. Major changes to plant operating documents, such as operating and maintenance procedures, should be identified.

2.3.6 Utility Licensing

Included in this category are activities such as identification of major licensing documents that may require changes as the result of the requirement, preparation and delivery of legal testimony, and negotiations with the NRC or other government agencies in preparing the requirement resolution. The important areas to identify here are the licensing documents that require changes, the need for public hearings or other special legal requirements, and out-of-the-ordinary negotiations in which the utility may become involved. Fees paid by utilities to government agencies such as the NRC and the U.S. Environmental Protection Agency (EPA) are not included here because they will be captured as a cost to these agencies in developing and implementing the requirement.

2.3.7 NRC Activities

Activities conducted by the NRC, whose cost is attributed to the requirement being analyzed, include the effort needed to implement the generic requirement for the reference plant; and the Inspection and Enforcement (I&E) activities needed to inspect the changes at the reference plant (including any periodic I&E activities that must be carried out over the life of the plant). Special attention should be paid to the provisions of the requirement that may identify special I&E activities needed during implementation and throughout the life of the plant. In the prioritization of efforts to resolve a generic issue, NRC costs will, in addition, include the work needed to develop the requirement into its final form for approval, including review by the Committee to Review Generic Requirements (CRGR), Advisory Committee on Reactor Safeguards (ACRS), and the public.

2.3.8 Other Government Activities

This category includes activities required of other government agencies (federal, state, or local) because of the requirement being evaluated. Examples might include changes to the environmental impact statement, changes in the emergency plan, or granting of special permits or licenses.

3 REPLACEMENT ENERGY COSTS

Section 2.3.1 of this handbook identified four separate cost components that could contribute to the total lifetime replacement energy cost for a nuclear plant because of regulatory requirement. These are the plant shutdown cost, reduced power cost, change in capacity factor cost, and change in net electrical output cost. The first two are one-time costs incurred as a result of the plant being off-line completely or in a reduced power mode while the change is being implemented, while the last two are costs that accumulate over the remaining life of the plant. Data Sheet 3.1 lists the various factors that, when present to a significant extent, must be determined in order to calculate these four cost components. Each of these factors is defined below.

3.1 REPLACEMENT ENERGY COST FACTORS

Net Electrical Output (E): Net busbar output of the plants, in kW_e .

Change in Net Electrical Output (E_C): Change in busbar output (kW_e) that would result from changes in the in-house electrical load because of the requirement. This change could be positive or negative.

Percentage of Power Reduction (Q): Power level of the plant, expressed as a percentage of the net electrical output, to which the plant(s) would be restricted while implementing the plant changes.

Change in Capacity Factor (P_F): Change in the plant capacity factor, expressed in percentage points, expected as a result of implementing the requirement. This could be either an increase or decrease in capacity factor. For the purposes of this cost analysis, a reduction in capacity factor will be expressed as a (+) change while an increase will be expressed as a (-) change.

Shutdown Period (P): The number of hours, attributed to the implementation of the requirement being evaluated, that the plant is out of commercial service. For requirements leading to a forced outage of the plant or where no clear justification exists for prorating the shutdown period over other activities, e.g. refueling, the full duration of the shutdown period will be used.

Reduced Power Period (T): The number of hours, at the power level Q above, attributed to the requirement. The same ground rules used for assigning the value for P above are used here.

Replacement Energy Charge Rate (R): The charge rate, expressed in $\$/\text{kWh}$, applicable to the plant(s) being evaluated. For this handbook, where rough, order-of-magnitude estimates are desired, it should be sufficient to use regional average or national average values for the replacement energy charge rate. Table 3.1 provides a listing of the average replacement energy charge rate (expressed in $\$/\text{kWh}$) for each of the nine North American Electric Reliability Council (NERC) regions identified in Fig. 3.1. A national average replacement energy cost value has also been estimated at 0.026 $\$/\text{kWh}$.

DATA SHEET 3.1 Replacement Energy Cost

Requirement Name:

Plant Name:

NERC Region:

Reference Plant Name:

Type of plant (BWR or PWR):

Net Electrical Output - E (kW_e):

Change in Net Electrical Output - E_C (kW_e):

Percent Power Reduction - Q (%):

Percent Change in Capacity Factor - P_F (%):

Shutdown Period - P (hr):

Reduced Power Period - T (hr):

Replacement Energy Charge Rate - R (\$/kWh, 1985):

Multiplant Factor - M :

Remaining Plant Operating Life - L (yr):

Discount Rate - D :

FIGURE 3.1 Regions of the North American Utility Reliability Council

These average replacement energy costs were derived from a study sponsored by the NRC Cost Analysis Group.² The data, assumptions, and methodology, as well as much more refined estimates, are available in this reference. For example, that report contains seasonally adjusted estimates for each of the 108 nuclear units scheduled to be operational by summer 1986. Also, for additional insight into applying these estimates to specific regulatory impact analyses, the reader is referred to *Generic Cost Estimates - Abstracts from Generic Studies for Use in Preparing Regulatory Impact Analyses*.³ This catalog is available from the Cost Analysis Group and is designed to facilitate NRC analysts' use of the more detailed generic cost estimates.

Multiplant Factor (M): A multiplying factor applied to the charge rate R when several nuclear plants are required to be shut down simultaneously in the same power pool. For this evaluation, this factor can be assumed to be 1 for up to a five-unit shutdown in a single power pool. For more than a five-unit shutdown in one power pool, the user should consult Appendix B of Ref. 2 for information on a suitable multiplant factor.

3.2 OTHER RELATED FACTORS

Remaining Plant Lifetime (L): The remaining plant operating life, expressed in years, for the plant being evaluated. For this analysis, all plants can be assumed to have operating lifetimes of 30 years from the date of their initial commercial operation. In an evaluation of large numbers of plants using the national or regional average replacement energy values, an average lifetime for all plants should be estimated.

Discount Rate (D): To calculate the estimated total lifetime present value of a requirement, NUREG/BR-0058 stipulates that a discount rate of 10% be used.⁴ Other discount rates may also be used to test the sensitivity of the analysis, and therefore it is recommended that a value of 5% also be included in the sensitivity assessment.

TABLE 3.1 Regional Average Replacement Energy Charge Rates per Kilowatt-Hour^a

NERC Regions	Rate (\$/kWh)
ECAR	0.020
ERCOT	0.035
MAAC	0.030
SPP	0.024
WSCC	0.037
MAIN	0.023
MAPP	0.011
NPCC	0.040
SERC	0.024
National Average	0.026

^aDollar values derived from Ref. 2.

3.3 REACTOR IS TAKEN OUT OF COMMERCIAL OPERATION DURING MODIFICATION

If it is concluded that implementation of the modification will require the reactor to be out of commercial service, replacement energy costs will very likely be incurred. Frequently however, the modification can be performed during the next available outage (e.g., refueling, maintenance, etc.). Even in these circumstances, however, it is likely that the modification will extend the duration of that next available outage, and thus a portion of the outage period should be used in calculating a replacement energy cost penalty.

This plant shutdown cost (C_{RS}) can be calculated by multiplying the appropriate average replacement energy charge rate (R) times the estimated average incremental shutdown time (P) per reactor times the total net electrical output of all impacted reactors (E). If regional average replacement energy charge rates are used, the analyst must first break down the affected reactor population by NERC region, calculate the replacement energy cost penalty by region, and sum over all the regions.

3.4 REACTOR'S POWER LEVEL IS REDUCED DURING MODIFICATION

If the reactor can remain in commercial operation during the modification but must operate at a reduced power level (e.g., 50%), the reduced power cost penalty (C_{RP})

is calculated by multiplying the appropriate average replacement energy charge rate (R) times the average number of hours the reactor will be at reduced power (T) times the estimated average percentage reduction in power (Q) times the total net output of all reactors (E).

3.5 REACTOR'S FUTURE PERFORMANCE OR AVAILABILITY IS ALTERED BY MODIFICATION

If the modification is expected to have a long-term adverse effect on the performance or availability of a reactor, the lower annual energy output can be translated into a reduced capacity factor for the reactor(s) (e.g., prior to modification, a reactor performed at an average capacity factor of 70%, but additional inspection and test requirements are expected to reduce the average capacity factor in the future to 65%). The change in capacity factor cost penalty (C_{RF}) is calculated by multiplying the appropriate replacement energy charge rate (R) times 8760 (hours) times the percentage change in the capacity factor (P_F) (in our example, $5\%/70\% = 0.071 = 7\%$) times the total net output of all impacted reactor(s) (e.g., 20 years) and discounted to the present to obtain the lifetime present worth of this cost stream.*

Newly proposed NRC regulatory requirements can also result in long-term improvements in a power reactor's performance/availability. These effects can be quantified in the same fashion but would appear as cost savings in the value-impact assessment in arriving at the net cost to the industry.

3.6 REACTOR'S NET ELECTRICAL OUTPUT IS ALTERED BY MODIFICATION

If modification will require an in-plant electrical load to service its operation, the net electrical output (net busbar kW_e) available to service the utility's customers will be reduced; e.g., prior to modification, reactor has 1000 MW_e available to service utility customers, but new requirement will consume 10,000 kW_e when unit is operational. The change in net electrical output cost penalty (C_{RO}) is obtained by multiplying the appropriate average replacement energy charge rate (R) times 8760 (hours) times the average percentage change in net electrical output (E) (in our example, 10,000 kW_e) times the number of impacted reactors. Because this is assumed to be a recurring long-term cost, this result must be multiplied by the average remaining life (L) of an affected reactor (e.g., 20 years) and discounted to the present to obtain the lifetime present worth of this cost stream.

Alternatively, a proposed modification could improve a plant's net electrical output by eliminating certain in-plant electrical loads. These effects can be quantified in the same fashion but would appear as cost savings in the value-impact assessment in arriving at the net cost to the industry.

*For guidance on discounting and present worth calculations, see NUREG/CR-3568, A Handbook for Value-Impact Assessment, by Pacific Northwest Laboratory.¹⁵

Worksheet 3.2 can be used to calculate each of the four components of the total lifetime replacement energy cost. Note that the components C_{RS} and C_{RP} are lump-sum costs that will be expressed in 1984 dollars. Components C_{RF} and C_{RO} represent the present lump sum values for annual costs that will accrue over the remaining plant lifetime. As pointed out in Chapter 2, the capacity factor could increase for a particular plant as a result of adding more safety-related equipment. In this case, the value of C_{RF} could represent a negative cost that would be added algebraically to the other cost components to determine the total lifetime replacement energy cost (C_{RL}).

3.7 CAVEATS

- Individual plant replacement energy charge rates can deviate from the regional average values by as much as a factor of two and can deviate from the national average estimate by as much as a factor of three. The use of either the regional average or national average value to estimate the replacement energy costs for a single plant or for small numbers of plants can introduce large uncertainties in the result.
- Replacement energy charge rates are expressed in 1984 dollars and reflect utility supply and demand conditions in the 1985-86 timeframe. If a cost analysis is being performed in dollars other than 1984, costs should be adjusted by rate of general inflation. If shortterm outage is expected to occur beyond the 1985-86 timeframe, check with Cost Analysis Group for availability of updated values.
- If more than five reactors in the same power pool are expected to be down at the same time, higher than average replacement energy costs are to be expected. See Appendix B in Ref. 2 for information on evaluating an appropriate multiplant factor.
- The replacement energy charge rates are based on power pool simulations and supply and demand considerations that capture a utility's response to a near-term short duration loss of a nuclear power reactor similar to the scenarios described in Secs. 3.3 and 3.4. However, in Secs. 3.5 and 3.6, these estimates are used as proxies to reflect costs incurred over long durations and into time periods well beyond the original study timeframe. A utility's response to a long-term loss of capacity can be markedly different than a short-term remedy. Similarly, supply and demand conditions that controlled these cost estimates may no longer be relevant in future years. An NRC user should alert his audience to these discrepancies whenever applying these replacement energy charge rates to long-term future year impacts.

WORKSHEET 3.1 Replacement Energy Cost**Requirement Name:****Reference Plant Name:****Replacement Outage Cost Calculations:**

- Plant Shutdown Cost (C_{RS}) = $E \times P \times R$
- Reduced Power Cost (C_{RP}) = $E \times \frac{Q}{100} \times T \times R$
- Change in Capacity Factor Cost (C_{RF}) = $E \times 8760 \times \frac{PF}{100} \times R$

$$\times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]^*$$
- Change in Net Electrical Output Cost (C_{RO}) = $E_C \times 8760 \times R$

$$\times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]^*$$

$$\text{Total Lifetime Replacement Energy Cost } (C_{RL}) = C_{RS} + C_{RP} + C_{RF} + C_{RO}$$

*Two rule-of-thumb approximations that are helpful in evaluating this expression are the rules of 72 and 35. These rules state that the discount factor -- $(1 + D)^L$ -- is 2 when the product of the discount rate (D), expressed in percent, and the remaining plant life (L), in years, is 72; and the discount factor is 1.4 when the product is 35.

4 PLANT STRUCTURES

For many proposed regulatory requirements, plant structure costs can be an important consideration in an overall cost estimate. The effects of a regulatory requirement on the various plant structures will generally be felt in one of three ways: (1) requiring greater utilization of existing structures by using space for new equipment or structural components, (2) requiring that existing structures be modified to house new equipment or structural components, and (3) requiring that new structures be built to house new equipment.

This section provides an approach to developing meaningful order-of-magnitude estimates of these plant structure costs. Basically, the approach requires that the analyst match, as closely as possible, the technical specifications of the structures affected or needed for the plant changes to the structures contained in the nuclear cost data base, and then adjust the data base costs to account for specific conditions surrounding the modification in question.

4.1 NUCLEAR COST DATA BASE

4.1.1 Identifying Analogous Structures

The data base from which the reference plant costs will be derived is the Energy Economic Data Base (EEDB) Phase VI Update published in 1984 by the U.S. Department of Energy.⁶ A description of this data base is also available in Sec. 4 and Appendixes C and D of the NRC's Handbook for Cost Estimating.¹ The EEDB covers BWR and PWR reference plants and includes detailed technical design and engineering cost estimates. Costs and design features are periodically updated to ensure that reference costs reflect current requirements, prices, and wage rates. For cost estimating (e.g., labor rates, material, and transportation costs, etc.), the plants have been located on a hypothetical "Middletown" site in the northeastern United States near a medium-sized (500,000-1,000,000 population) light industrial city. A complete technical description of this site can be found in Appendix A-1 of the EEDB's Technical Reference Book⁷.

This Technical Reference Book (TRB) contains sections that describe in considerable detail the overall technical design for the reference BWR and PWR plants. These are found in Secs. 3 and 4, respectively, of the TRB. With the aid of these technical descriptions, the user of this handbook should be able to identify the structure(s) in the EEDB that are analogous to the structures of the plant being evaluated that will be affected by the proposed requirement.

A series of technical specifications should be considered when comparing the EEDB structures with the structural requirements of the plant being evaluated. These specifications or design features should include -- as a minimum -- overall building size, building structural requirements and composition, building service requirements, and special features.

- **Building Size:** The overall dimensional requirements for the building(s) should be determined. These include the volume requirements for equipment to be housed in existing buildings, the volumes of additions or modifications to existing structures, and the dimensions of new structures required.
- **Structural Requirements:** These might include the type of foundation required, the seismic classification and design-basis ground acceleration, the need for tornado missile and sabotage protection, etc.
- **Structural Composition:** Based on the above structural requirements, the basic composition of the structure should be determined. Is the building of poured/reinforced concrete, prestressed concrete, steel framing, etc.?
- **Building Service Requirements:** What are the heating, ventilation, and air-conditioning (HVAC) requirements? Are there special atmospheric filtration requirements? Special attention should be paid to identifying out-of-the-ordinary requirements when compared with similar structures at the data base plants.
- **Special Features:** It is important to identify special features that could have a significant cost effect. Features such as extra-thick shield walls, the use of high-density or steel aggregate concrete, and special reinforcing are examples of such special features.

4.1.2 Identifying Baseline Costs from the EEDB

The technical description of the structures in the TRB conform directly to the code-of-accounts breakdown of EEDB cost estimates. Thus, once a specific structure(s) has been identified in the TRB, one can use the code-of-account number to go directly to the EEDB cost estimate. This code-of-accounts is structured around a nine-digit numbering scheme that breaks down a complex structure or system into succeeding more detailed subdivisions until, at the nine-digit level of detail, individual components are identified and costed. Table 4.1 is a sample breakdown of the code-of-accounts for the direct costs of the waste processing building. To point out some highlights of this breakdown, at the four-digit level, the building structure and building service systems are delineated and costs are subtotaled at that level. Appendix C of this handbook contains the full four-digit breakdown of both the BWR (Table C.1) and PWR (Table C.2) EEDB-VI cost estimates. These costs have been evaluated and are expressed in 1983 dollars on an overnight cost basis; that is, the plant costs are expressed as if they were incurred overnight and do not include any interest or escalation. Note that all of the structures are listed first (the 21 account), the equipment is listed next (the 22-26 accounts), and the indirect costs (the 9-series accounts) are listed last. Each cost line item is divided into the factory equipment (C_E) site materials (C_M), and total site labor (C_L) needed to install the equipment and materials, for the item identified. As indicated

TABLE 4.1 Energy Economic Data Base Code of Accounts: Example of Levels of Detail

Number of Digits	Number	Name of Account	Function/Level
1	2	Direct costs	Total/"Bottom Line"
2	21	Structures and improvements	Name/Account
3	216	Waste processing building	Name/Structure
4	216.1	Building structure	Name/Category
5	216.14	Superstructure	Name/Subcategory
6	216.141	Concrete work	Class/Category
7	216.1411	Form work	Class/Subcategory
8	216.14112	Form work -- metal	Class/Sub-Subcategory
9	216.141121	Form work -- metal tie rods	Class/Component

above, the EEDB contains breakdowns beyond the four-digit level. If a more detailed individual component cost breakdown (e.g., nine-digit) is required, the NRC analyst should go directly to the EEDB. The Cost Analysis Group in the NRC Office of Resource Management maintains complete current copies of the EEDB.

4.2 ADJUSTMENT TO EEDB COST ESTIMATES

With the EEDB estimate for an analogous structure now in hand, the NRC analyst should begin to identify and apply cost factors to adjust the EEDB baseline cost to the specific conditions of the plant being evaluated. Adjustments are required for a number of reasons. First, the EEDB expresses costs only under new construction conditions, whereas NRC requirements may be imposed on new plants, plants already operational, or already well under construction. These latter conditions can considerably alter labor productivity and rework requirements relative to the EEDB results. Second, structure costs will have associated engineering and quality control efforts associated with them. The EEDB aggregates these effort costs as a single value for the plant and does not provide a way to allocate these labor efforts among structures or systems. This is corrected for in this report. Third, the EEDB provides costs only at a single site location, and adjustments might be required to account for regional variations in labor and material costs. Although these adjustments should improve the estimating capability of the EEDB for NRC regulatory analyses, the user is cautioned that each cost analysis will likely contain a number of unique circumstances that could require further adjustments to the EEDB baseline cost estimate. Here, it is the responsibility of the NRC analyst to identify important differences and provide a basis for further refinement of the EEDB cost estimate.

4.2.1 Labor Productivity Cost Factors

Labor productivity cost factors account for the differences in labor productivity at new construction sites vs. construction work to be performed at operating plants and plants well along in construction. Four such factors have been identified:

Access and Handling Factor (F_{LA}): This factor incorporates site restrictions and security procedures, but more importantly, material and equipment transportation complications. Transportation complications include distance from storage sites, additional handling due to pathway encumbrances such as hatchways, and possible difficulties in moving to elevated locations.

Congestion and Interference Factor (F_{LC}): This factor refers to the physical conditions of the actual work site. Congestion can be interpreted as limitations on the ability (1) to maneuver equipment and materials freely and (2) of individuals to perform their tasks unhindered. Severe congestion suggests the inability to function except in extremely restricted positions.

Radiation Factor (F_{LR}): This refers to the protective measures necessary for individuals to function in certain environments at operating reactors. Productivity is affected through the limitations imposed by required equipment, e.g., respirators, and by strict time limitations on individual exposures (stay time). Radiation is obviously not a factor applicable to non-operating reactors. High ambient temperatures that frequently accompany radiological conditions are exacerbated by equipment requirements and also contribute to lowered productivity.

Manageability Factor (F_{LM}): This concept refers not only to the individual task but to the overall management environment within which it is performed. Generally speaking, evidence suggests that productivity tends to decline as management complexity increases, and that management complexity can be approximated by the size of the work-force on site. For operating reactors, this leads to the conclusion that productivity falls for work undertaken during scheduled plant outages. However, for non-outage work, labor productivity is probably more productive than that performed at a new construction setting.

Another influence applicable to operating reactors is the ability to complete advance engineering work before shutdown. In areas inaccessible during plant operation (principally areas within the containment), retrofit planning can only be completed preliminarily until access is possible after shutdown. This can lead to rework that would have been prevented under more accessible conditions.

Table 4.2 provides suggested values for each of the four productivity factors for both operating plants and plants already under construction. Based on one's knowledge of the work environment in which the specific structure work will be performed, one should select the most appropriate values. Choosing the most appropriate values for quick, approximate estimates is relatively straightforward because the values for these factors are based on rather clear-cut guidelines.

TABLE 4.2 Labor Productivity Factors

Activity			Productivity Factor				
Access and Handling (operating plants)	Operating plant, security procedures, easy access, adequate laydown	0.1	Operating plant, noncontainment RWP restrictions, extra handling, limited laydown	0.3	Operating plant, containment area, extra handling; restricted laydown prefabrication and shakeout potential	0.4	----
Access and Handling (plants under construction) ^a	Under construction, easy access adequate laydown	0.0	Under construction internal area, extra handling, limited laydown	0.2	Under construction, containment area, extra handling; restricted laydown, prefabrication, and shakeout potential	0.4	----
Congestion and Interference ^b	Uncongested work area	0.0	Congested work area	0.2	Severely congested work area	0.4	----
Radiation ^c	No radiation	0.0	Minimal equipment (respirator)	0.2	Full protective	0.5	High radiation, high temperature; stay time ^d of 2 hr = 1.1; 1 hr = 2.6; 0.5 hr = 5.6
Manageability ^c	Non-outage related	(0.2)	Outage activity	0.3	Outage activity within containment	0.4	----

^a"Under construction" generally denotes plants more than 70% complete.

^bApplies to both operating plants and plants under construction.

^cNormally applies to operating plants only.

^dSee text for basis of stay-time factors.

For additional insight into applying these estimates to specific regulatory impact analyses, the reader is referred to the catalog titled *Generic Cost Estimates - Abstracts from Generic Studies for Use in Preparing Regulatory Impact Analyses*.³ For a complete discussion, including bases for these cost factors and illustrative examples of how they can be used, the NRC analyst is referred to the Cost Analysis Group's study entitled, *Labor Productivity Adjustment Factors*.⁸ The catalog and underlying generic study are available from the Cost Analysis Group and should enhance one's knowledge and ability to use these cost factors.

4.2.2 Structural Rework Cost Factor

The structural rework cost factor (F_{SR}) accounts for the added labor in preparing an existing building before a modification to that structure can be made. Typical rework might include changing internal walls, building new support foundations for equipment, and changing major components of the building service equipment, etc. An allowance for this consideration is currently somewhat subjective. No systematic study of this factor is known to the author, and the recommended values reflect solely this author's best judgment. Recommended values for this factor are:

Plants up to 70% complete	0 (no adjustment)
Plants between 70% and 100% complete	0.5
Operating plants	1.0

4.2.3 Regional Cost Factors

The inclusion of regional cost factors (F_M and F_L) was considered to account for variations in labor rates and material costs among various regions of the country. This review concluded that *for purposes of gross estimation*, variations were so small as to not warrant further adjustment. However, Appendix D contains a wide range of index values that should be considered if greater precision is sought or if a cost analysis is limited to one or only a few plants.

4.2.4 Structural Engineering and Quality Assurance/Control Cost Factor

This factor (F_{SD}) accounts for the cost of engineering and design, as well as quality assurance (QA) and quality control (QC) activities, associated with implementing a requirement. A study of the relationship of these costs with the total direct cost of material, equipment, and labor has been conducted by United Engineers and Constructors⁹ under contract to NRC. This study concluded that a reasonable approximation of the combined cost for engineering, design, QA, and QC can be obtained by using factors of 15% for changes to plants well along in construction and operating plants, and 33% for new plants. For the rough cost estimates sought in this handbook, these factors should provide cost estimates of an accuracy consistent with the rest of the handbook. The detailed results of this study showed a wide variation in the value of this factor on a structure-by-structure or system-by-system basis. The basis for these values

and a more detailed breakdown of engineering and quality control costs by EEDB code of accounts is available in *Engineering and Quality Assurance Cost Factors*, by United Engineers and Constructors.⁹ For additional insight into applying the more detailed results to specific regulatory analyses the reader is also referred to Ref. 3.

4.3 ESTIMATING STRUCTURE COSTS

Having identified the EEDB baseline cost estimate for an analogous structure, as well as the generic cost factors to adjust the baseline estimate, one can now perform the calculations associated with implementation of the requirement. The structural costs are divided into three areas: (1) the cost of utilizing an existing structure, (2) the cost of modifying a structure, and (3) the cost of building a new structure. Data Sheet 4.1 will assist the user in identifying the various quantities that could be needed to calculate these costs.

4.3.1 Cost of Utilizing an Existing Structure

If one can readily conclude that the volume of equipment or space required to accommodate a proposed regulation can be readily housed within an existing structure, the cost calculation is relatively uncomplicated and straightforward. Technically, in this situation no out-of-pocket structure costs will be incurred by industry. However, the NRC recognizes that existing space at a nuclear power plant is limited and that any incremental requirement that affects available space creates an opportunity cost. That is, although this requirement may not require a physical modification or new building, it will hasten the day when such a modification or new structure will have to be considered. To capture this effect, it is appropriate to charge part of the initial cost of the existing structure against this new requirement.

To assist in this calculation, Table 4.3 provides the average cost per cubic foot of space for each of the major structures in a reference BWR and PWR. Thus, once one estimates the space (volume) a regulatory requirement will need and which structure it will be located in, the structure cost can be calculated by multiplying the volume requirement of the new regulation V_E (to be estimated by user) by the cost per cubic foot for the appropriate structure C_{VU} (available in Table 4.3). For example, if a new regulation will require 1000 ft^3 of space in the control room for 50 PWRs and in all cases the control rooms can accommodate this requirement, the cost calculation for utilizing an existing structure is $\$23.70/\text{ft}^3 \times 1000 \text{ ft}^3 \times 50 \text{ (plants)} = \$1,185,000$. Worksheet 4.1 can be used to calculate the cost of structural utilization.

4.3.2 Cost of Modifying a Structure

Modifying an existing structure will typically include reworking existing structure and/or adding to an existing structure.

WORKSHEET 4.1 Structural Utilization Costs**Requirement Name:****Reference Plant Name:****Reference Structure:****Analogous Data Base Structure:****Cost of Data Base Structure:**Equipment (C_E): Materials (C_M): Labor (C_L):**Total Data Base Cost (C_{SDB}) = $C_E + C_M + C_L$** **Weighted Regional Cost Adjustments:**

$$C_M' = \frac{C_M}{C_{SDB}} \times F_M \qquad C_E' = \frac{C_E}{C_{SDB}}$$

$$C_L' = \frac{C_L}{C_{SDB}} \times F_L$$

Structural Utilization Cost (C_{SU}) = $V_E \times C_{VU} \times (C_M' + C_L' + C_E')$

DATA SHEET 4.1 Technical and Cost Data for Plant Structures

Requirement Name:

Reference Plants

Plant Name:

Percent Complete:

Structure Name:

Seismic Classification:

Special Features:

Volume Requirements - V_R (ft³):

Existing Volume Utilization - V_E (ft³):

Rework Volume - V_{RE} (ft³):

Addition Volume - V_{AD} (ft³):

Data Base Plant

Analogous Structure Name:

Seismic Classification:

Structural Composition:

Volume of Analogous Structure - V_A (ft³):

Volume Utilization Cost - C_{VU} (\$/ft³):

Analogous Structure Cost (\$):

EEDB Account No.:

Equipment - C_E : Materials - C_M : Labor - C_L :

Engineering and QA Cost Factor for Analogous Structure - F_{SD} (%):

Cost Factors

Congestion Productivity Factor - F_{LC} :

Radiation Productivity Factor - F_{LR} :

Access Productivity Factor - F_{LA} :

Manageability Productivity Factor - F_{LM} :

Regional Materials Cost Factor - F_M :

Regional Labor Cost Factor - F_L :

Structural Rework Cost Factor - F_{SR} :

TABLE 4.3 Incremental Utilization Costs for Major Structures

Structure	Seismic I	1983 Cost ^a (\$/ft ³)	
		BWR	PWR
Containment	Yes	39	29.8
Turbine Building	No	5.1	4.3
Security Building	No	27.5	28.1
Primary Auxiliary Building	Yes	30.1	20.5
Waste Process Building	(Partial)	22.9	10.9
Fuel Storage Building	Yes	8.9	16.3
Control Room/Diesel Generator Building	Yes	23.7	15.2
Administration and Service Building	No	5.7	5.6
Fire House	No	14.0	14.0
Emergency Feed Pump Building	Yes	--	48.5
Main Stream and Feed Water Pipe Enclosure	Yes	--	38.5
Technical Support Center	No	9.2	10.3
Ultimate Heat Sink Structure	Yes	5.1	5.1

^aEvaluated from EEDB Phase VI Update report (Ref. 6) data on structure costs and structure volumes. These costs represent the total cost of the building (structure + building services).

4.3.2.1 Rework of an Existing Structure

The rework calculation is a function of:

- The estimated volume (ft³) of the existing structure that will require reworking, to be estimated by user (V_{RE}).
- The total volume (ft³) of the analogous structure, available from EEDB (V_A).
- The equipment (C_E), labor (C_L), and material (C_M) costs for the analogous structure, available from EEDB.
- The cost factors to account for labor productivity (F_{LR} , F_{LC} , F_{LA} , F_{LM}), rework (F_{SR}), and engineering-quality control activities (C_{SD}), available from Sec. 4.2.

The rework cost = C_{SR} . Thus:

$$C_{SR} = \frac{V_{RE}}{V_A} \times [C_E + C_M + C_L \times (1 + F_{SR} + F_{LC} + F_{LR} + F_{LA} + F_{LM})] \times (1 + F_{SD})$$

For example, an analogous structure in the EEDB has a total volume of 10,000 ft³ and equipment, labor, and material costs of \$1 million, \$5 million, and \$3 million, respectively. The modification is to occur in an operating reactor and will involve reworking 2000 ft³ of the structure volume. Cost factors for productivity are estimated to be:

- 1.0 for reworking (F_{SR}).
- 0.1 for access and handling (F_{LA}).
- 0.2 for congestion and interference (F_{LC}).
- 0.2 for radioactivity (F_{LR}).
- 0.3 for manageability (F_{LM}).

The structural engineering and QA cost factor (C_{SD}) is estimated to be 19%.

Therefore, the rework cost (C_{SR}) =

$$C_{SR} = \frac{2000}{10000} \text{ ft}^3 \times [\$1 \times 10^6 + \$3 \times 10^6 + \$5 \times 10^6 \times (1 + 1.0 + 0.2 + 0.2 + 0.1 + 0.3)] \times (1 + 0.15)$$

$$C_{SR} = 0.2[\$1,000,000 + \$3,000,000 + \$5,000,000(2.8)]1.15 \\ = \$4,140,000$$

4.3.2.2 Addition to an Existing Structure

Calculation of the cost of an addition to an existing structure (C_{SA}) closely parallels that of the rework cost. Here, however, the rework cost factor (F_{SR}) drops out, and the estimated volume of the existing structure that will require rework (V_{RE}) is replaced by V_{AD} , which is the estimated volume of the addition to the existing structure (this must be estimated by the user based on his knowledge of the modification). The appropriate equation is:

$$C_{SA} = \frac{V_{AD}}{V_A} \times [C_E + C_M + C_L \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{SD})$$

WORKSHEET 4.2 Structural Modification Costs

Requirement Name:

Reference Plant Name:

Percent Complete:

Reference Plant Structure:

Analogous Data Base Structure:

Cost of Data Base Structure:

Equipment (C_E): Materials (C_M): Labor (C_L):Regional Cost Adjustments: $C_M' = C_M \times F_M'$

$$C_L' = C_L \times F_L'$$

- Rework of an Existing Structure

$$\begin{aligned} \text{Structural Rework Cost } (C_{SR}) &= \frac{V_{RE}}{V_A} \times [(C_E + C_M' + C_L') \\ &\quad \times (1 + F_{SR} + F_{LC} + F_{LR} + R_{LA} + F_{LM})] \\ &\quad \times (1 + F_{SD}) \end{aligned}$$

- Addition to an Existing Structure

$$\begin{aligned} \text{Structural Addition Cost } (C_{SA}) &= \frac{V_{AD}}{V_A} \times [(C_E + C_M' + C_L') \\ &\quad \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \\ &\quad \times (1 + F_{SD}) \end{aligned}$$

- Total Structural Modification Cost (C_{SM}) = $C_{SR} + C_{SA}$

Adopting the same values as in the previous example (including setting $V_{AD} = 2000 \text{ ft}^3$) results in a cost estimate of:

$$C_{SA} = \frac{2000}{10000} \text{ ft}^3 [\$1 \times 10^6 + \$3 \times 10^6 + \$5 \times 10^6 \times (1 + 0.2 + 0.2 + 0.1 + 0.3)] \times (1 + 0.15)$$

$$C_{SA} = 0.2[\$1,000,000 + \$3,000,000 + \$5,000,000(1.8)]1.15$$

$$= \$2,990,000$$

The lower cost for the addition relative to reworking an existing structure for equivalent space is consistent with realistic industry experience. Not only will a rework cost factor not apply, but, on average, certain of the labor productivity cost factors are expected to take on lower values because the work area should be less constrained relative to attempting to perform work in an existing building. Worksheet 4.2 can be used to calculate the structural modification costs.

4.3.3 Cost of a New Structure

The equation for estimating the cost of a new structure (C_{ST}) is:

$$C_{ST} = \frac{V_R}{V_A} \times [C_E + C_M' + C_L' \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{SD})$$

Here, V_{AD} from the previous case is replaced with V_R , the estimated volume (ft^3) of the new structure. In all other respects the equations are identical and thus, for example, if the same space requirement were to be met by either an addition or a new structure, the resulting cost estimate would be the same. However, the user should be aware that, on average, volume requirements for an equivalent modification should be lower for an addition because of the potential to utilize existing substructures and equipment (e.g., common wall, building service equipment, etc.). Worksheet 4.3 can be used to calculate the costs for new structures.

4.4 CAVEATS

- The user is reminded that this approach is a gross estimating tool that can produce sizable discrepancies from detailed cost engineering evaluations. However, for many NRC regulatory actions, this type of analysis should provide a reasonable measure of the structure costs. Clearly, the more important and controversial the proposed action, the less desirable are the results obtained in this fashion.

- In most cases, special and unique circumstances are likely to exist relative to the structure requirements for a specific modification. The user's detailed knowledge of the proposed requirement is an important input that should be used to modify these results as one deems necessary.
- Depending on the version of the EEDB that the user is relying upon, baseline cost estimates will reflect costs as of a certain year. For example, the EEDB baseline costs presented in this report express BWR and PWR costs in 1983 dollars. All dollar costs should be escalated to the year in which the cost analysis is being performed. The GNP implicit price deflator is recommended as the basis for capturing the overall change in the value of the dollar. DOE is currently updating the PWR estimate, and the NRC's Cost Analysis Group is updating the BWR costs. When these are completed (late 1986), both reference plants will capture all nuclear power plant requirements through January 1985, and cost estimates will be available in 1985 dollars.

WORKSHEET 4.3 New Structure Costs**Requirement Name:****Reference Plant Name:****Analogous Data Base Structure:****Cost of Data Base Structure:**Equipment (C_E): Materials (C_M): Labor (C_L):**Regional Cost Adjustments:**

$$C_M' = C_M \times F_M$$

$$C_L' = C_L \times F_L$$

New Structure Cost (C_{ST})

$$= \frac{V_R}{V_A} \times [C_E + C_M' + C_L' \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{SD})$$

5 PLANT SYSTEMS AND HARDWARE

Another important cost category in the implementation of many proposed regulatory requirements is the cost of changes to plant systems and other hardware. These changes can involve installing complete new systems, reworking and/or modifying existing systems, and installing new components. Experience has shown that the cost of changes to plant hardware is strongly dependent on the status of the plant. For this reason, the approach presented here for estimating systems and hardware costs is designed to deal with new plants, plants under construction, and operating plants separately, using cost factors to deal with specific cost additions for each category or plant status.

The same basic approach that was used to evaluate the reference plant structural costs will be used to evaluate plant systems and hardware costs. That is, the system, subsystem, or individual component(s) needed to implement the requirement at the reference plant is matched with the analogous system, subsystem, or components(s) of the data base plant. The data base costs will then be adjusted for regional cost variations to determine a set of base case (new construction) costs at the reference plant site. The base costs are next adjusted for rework effects and the effects of adding equipment to a plant well under construction. The base case costs are also adjusted for rework effects and the effects of adding equipment to an operating plant.

5.1 IDENTIFYING ANALOGOUS SYSTEMS AND RELATED EEDB COSTS

Section 4.1 described the EEDB structure and format. For the purpose of evaluating systems or hardware costs, the user is referred to Table 5.1. This table

TABLE 5.1 Energy Economic Data Base: Example of Code of Accounts and Levels of Detail for Plant Systems and Hardware

Number of Digits	Account Number	Account	Function/Level
1	2	Direct costs	Total/"Bottom Line"
2	26	Main condenser heat rejection system	Name/Account
3	262	Mechanical equipment	Name/Subaccount
4	262.1	Heat rejection system	Name/System
5	262.15	Main cooling tower make- up and blowdown system	Name/Subsystem
6	262.151	Make-up water system	Name/Sub-Subsystem
7	262.1511	Rotating machinery	Class/Equipment Category
8	262.15111	Make-up pump and motor	Class/Equipment Subcategory
9	262.151111	Make-up pump	Class/Component

is a breakdown of the data base systems into successively higher levels of detail until, at the nine-digit level, individual components within a system are identified and costed. Technical descriptions of the plant hardware are also available at various levels of detail. The EEDB Technical Reference Book contains descriptions of all major systems for each of the data base models. In addition, the EEDB equipment list contains mini-specifications for all components in the model plants identified at the nine-digit level. Table 5.2 shows a typical mini-spec for a circulating water pump at the eight-digit level. This equipment list is available from the EEDB contractor. The user is urged to use the data base at the highest level of detail consistent with the technical details available for the hardware changes being evaluated and the level of precision desired for the cost estimate. Evaluating costs at the system level will allow estimates to be prepared more quickly, but with less precision. Evaluating hardware costs on a component-by-component basis will require considerably more effort but will generate more precise estimates. The cost estimating approach used here is compatible with whatever level of detail the user chooses to evaluate the systems costs. Appendix C contains the full four-digit breakdown of both the BWR and PWR EEDB-VI cost estimates. A full nine-digit level breakdown of the EEDB is available from the EEDB contractor.

A number of technical specifications are important to consider when comparing the EEDB systems with the systems requirements of the plant being evaluated. These specifications include nuclear safety class, redundancy requirements, materials, performance requirements, and special features.

- **Nuclear Safety Class:** For mechanical systems, safety classes can be Class 1, 2, 3, or non-nuclear. Electrical systems and components are typically Class 1-E or non-Class 1-E.
- **Redundancy:** This includes the need for fully redundant pairs of systems, the need for redundant loops or trains within a system, or the need for redundant components.
- **Materials:** Mechanical system requirements in particular can be very restrictive on the choice of materials acceptable for use and can specify exotic and expensive alloys.
- **Performance Requirements:** These include such items as capacity, operating temperature and pressure, horsepower, etc.
- **Special Features:** These can include any requirement leading to a special feature that would affect cost. Examples might include the need for special piping restraints, missile protection, radiation resistance, etc.

5.2 ADJUSTMENTS TO THE EEDB SYSTEMS COSTS

Chapter 4 identified several cost factors that can be used to adjust the EEDB costs to the specific conditions of the plant being evaluated. The labor productivity

TABLE 5.2 Mini-Specification - Circulating Water Pump

Equipment List - Report 1

Model 148 - 1139 MW_e/3425 MW_t PWR - 2.5 in. Hg av - Middletown, USA

Account Number	Item	Description	
262.1211	Circulating Water Pump with Motor		
262.12111	Circulating Water Pump	Quantity	4x25 pct
		Type	Mixed Flow
		Orientation	Vertical
		Speed	320 rpm
		TDH	105 ft
		BHP	4.414
		NPSH	30 ft
		Efficiency	88.6 pct
		Design Press	150 psia
		Design Temp	100°F
		Material	NI-Resit
			Col. & Bowl
			SS. Impeller
		Safety Class	NNS
		Seismic Cat.	None
		Design Code	
262.12112	Circulating Water Pump Motor	Quantity	4x25 pct
		Type	AC Induction
		Horsepower	5,000
		Speed	320 rpm
		Voltage	13.2 kV, 3-phase, 60 hz

factors defined in Chapter 4 are valid for adjusting the EEDB systems costs as well. In addition, there are adjustment factors specific to systems costs that can aid in adjusting the data base costs.

5.2.1 System Configuration Factors

These factors account for the appropriate portion of a data base system that will be used in modifying the reference plant and that portion of a data base system that must be reworked to implement the requirement. The cost of such rework is also a function of the safety class of the system.

Percentage of EEDB System/Subsystem Cost (P_Y): This is an estimate of the portion (expressed as a percentage) of the EEDB analogous system or subsystem cost that will be applied to the reference plant modification. This can be estimated by comparing such features as numbers of loops, major components, degree of redundancy, etc., in the reference system to the analogous system.

Percentage of Existing System Rework (P_{YR}): For an installed system that would have to be modified to implement the requirement, this is the estimated percentage of such a system that will require reworking. For example, if a portion of a system had to be relocated to provide room for components of a new system, P_{YR} would be the estimated percentage of the system to be relocated.

5.2.2 Other System-Related Factors

These factors address the costs for additional labor associated with reworking an existing system and the cost for engineering and QA.

Systems Rework Cost Factor (F_{YR}). This factor accounts for the additional labor needed to prepare the existing system identified with P_{YR} , for a modification either to itself or to another system or structure. A strong consideration in selecting a value for this factor is the safety class of the system being modified. No systematic study has been performed to determine the value of this factor for various safety classes. However, the user should be aware of this factor and should attempt to account for its effect in the cost estimate.

Systems Engineering and QA Cost Factor (F_{YD}). Section 4.2.4 provides cost factors (expressed as percentages of their respective direct systems costs) for new construction and for operating plants. These values, 33% and 15%, respectively, should also be used to calculate the engineering and QA costs for systems work. As stated in Chapter 4, the basis for these values is found in *Engineering and Quality Assurance Cost Factors*, by United Engineers and Constructors.⁹

5.2.3 Other Related Costs

In addition to those activities already identified that are directly related to the physical modification of the plant structures and equipment, other activities could be either directly or indirectly related to such modifications and that could add significant costs to implementing the requirement. Examples of such related activities include the unloading and reloading of the core, the removal and replacement of the containment equipment hatch, and the need to fill the containment with an inert atmosphere. The cost of such activities, if necessary to implement the requirement being evaluated, should be included in the estimate. It is incumbent on the user to be alert to these supporting activities and to apply the appropriate cost or portion of the cost to the requirement. The same ground rules should be applied to these costs that were applied to the replacement energy costs, i.e., if it is a necessary condition for implementing the requirement and cannot reasonably be attributed to another simultaneous activity at the plant, its cost should be attributed to the requirement.

Generic cost estimates have been made for plant startup and shutdown and the unloading and reloading of the core.¹⁰ In addition, the labor costs associated with removing and replacing the equipment hatch at a large PWR station has been estimated. These values are as follows:

<u>Reactor Plant Shutdown and Startup*</u>	<u>BWR</u>	<u>PWR</u>
Total Elapsed Time (hr)	36-84	48-100
Cost (1984 dollars)	6K-15K	7K-20K
<u>Core Unload and Reload</u>		
Total Elapsed Time (wk)	~6	~3
Cost (1984 dollars)	200-250K	120-150K
<u>Remove and Replace Equipment Hatch</u>		
Total Elapsed Time (hr)	---	~15
Cost (1985 dollars)	---	2-3K

5.3 ESTIMATING SYSTEMS COSTS

After identification is made of the EEDB analogous system, the EEDB baseline cost estimate for that system, and the various cost factors to adjust the baseline estimate, it is again possible to estimate the cost of implementing the requirement at the reference plant being evaluated. The system cost calculations are performed for the three plant status types.

The systems and/or equipment costs are estimated first on the basis of new plant construction (base case), adjusted for regional cost factors to the site of the reference plant. These base case costs can then be applied to the case for a plant well under construction or for an operating plant, whichever is appropriate for the reference plant being evaluated. Data Sheet 5.1 will assist the user in identifying the various quantities needed to calculate the systems costs.

5.3.1 New Plant (Base Case) System Costs

Because both the EEDB system costs and the base case costs are based on new plant construction, the base case costs can be prorated directly from the EEDB costs. Proration is based on the percentage of the EEDB system costs applicable to the base

*For additional insight into applying these estimates to specific regulatory impact analyses, the reader is referred to *Generic Cost Estimates — Abstracts from Generic Studies for Use in Preparing Regulatory Impact Analyses*.³ This catalog is available from the Cost Analysis Group and is designed to facilitate the NRC analyst's use of the more detailed generic cost estimates.

DATA SHEET 5.1 Technical and Cost Data for Plant Systems

Technical and Cost Data

Reference Plant

Plant Name:

Percent Complete:

System Name:

Safety Class:

Percentage of Existing System Rework - P_{YR} (%):

Data Base Plant

Analogous System/Component Name:

Safety Class:

Percent of System/Subsystem Cost - P (%):

Analogous System Costs (\$)

EEDB Account No.:

Equipment - C_E : Materials - C_M : Labor - C_L :

Engineering and QA Cost Factor

for Analogous System - F_{YD} (%):

Cost Factors

Congestion Productivity Factor - F_{LC} :

Radiation Productivity Factor - F_{LR} :

Access Productivity Factor - F_{LA} :

Manageability Productivity Factor - F_{LM} :

Regional Materials Cost Factor - F_M :

Regional Labor Cost Factor - F_L :

Systems Rework Cost Factor - F_{YR} :

case (P_Y). For example, if the requirement calls for the addition of a fully redundant leak detection system (EEDB Account #226.6), the EEDB systems costs (from Table C.2 in Appendix C) are:

$$\text{Equipment } (C_E) = \$147,000$$

$$\text{Labor } (C_L) = 21,000$$

$$\text{Materials } (C_M) = 1,000$$

The appropriate value for P_Y in this case is 100%, and therefore the prorated cost for the base case system is the sum of the three cost components times 100%, or:

$$(\$147,000 + 21,000 + 1,000) \times \frac{100}{100} = \$169,000$$

Adjustments for regional effects of the cost for labor or materials should be made to the individual prorated cost components.

Because the systems engineering and QA are expressed as a percentage of the total system cost (F_{YD}), the cost for engineering and QA in this example is:

$$\$169,000 \times 0.33 = \$55,800$$

The total system base cost (C_{YT}) is then the sum of the prorated base system cost and the engineering and QA cost, or:

$$\$169,000 + 55,800 = \$224,800$$

Worksheet 5.1 can be used to calculate this cost.

5.3.2 Systems Costs for Plants under Construction or Operating

If the reference plant being evaluated is operating or well along in construction, consideration must be given to the likelihood that existing systems will be affected by the modification that will lead to costs for modifying or reworking such systems in addition to the cost of any new systems or equipment. Adjustments must also be made to the base case costs to account for factors such as reworking existing systems, decreased labor productivity, etc., not found in the new construction case. To continue our example of adding a second leak detection system, the costs incurred at operating plants and plants well under construction will be a function of:

- The prorated equipment (C_{EP}), labor (C_{LP}), and materials (C_{MP}) costs for the analogous system.
- The estimated percentage of an existing system that requires reworking, to be estimated by the user (P_{YR}). For our example, assume that this is 10% of the existing leak detection system.

WORKSHEET 5.1 Costs for New Plants (Base Case)**Requirement Name:****Reference Plant Name:****Reference Plant System/Component:****Analogous Data Base System:****Cost of Data Base System/Component:**Equipment (C_E): Materials (C_M): Labor (C_L):**Prorated Costs:** (C_{EP}) = $C_E \times P_Y$, (C_{MP}) = $C_M \times P_Y$, (C_{LP}) = $C_L \times P_Y$

- Prorated Cost of Data Base System/Component Applied to Reference Case:

Equipment (C_{EP}):Materials (C_{MP}):Labor (C_{LP}):

- Regional Cost Adjustments (if appropriate):

$$C_{MP}' = C_{MP} \times F_M$$

$$C_{LP}' = C_{LP} \times F_L$$

$$\text{Base System Cost } (C_{YB}) = C_{EP} + C_{MP}' + C_{LP}'$$

- Base System Engineering and QA Cost (C_{YBD}) = $C_{YB} \times \frac{F_{YD}}{100}$

$$\text{Total System Cost } (C_{YT}) = C_{YB} + C_{YBD}$$

- The cost factors to account for labor productivity (F_{LR} , F_{LC} , F_{LA} , and F_{LM}), for rework labor (F_{YR}), and for engineering and QA (F_{YD}).
- Other related costs.

The cost calculations can be divided into two major categories: (1) the cost of reworking existing systems and/or components and (2) the cost of new systems or components. The network cost (C_{YR}) is:

$$C_{YR} = P_{YR} \times [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM} + F_{YR})] \times (1 + F_{YD})$$

where, for our example

$$P_{YR} = 10\%$$

$$C_{EP} = \$147,000$$

$$C_{LP}' = 21,000$$

$$C_{MP}' = 1,000$$

$$F_{LA} = 0.1$$

$$F_{LC} = 0.2$$

$$F_{LR} = 0.2$$

$$F_{LM} = 0.3$$

$$F_{YR} = 1.0$$

$$F_{YD} = 0.15$$

Therefore, the actual network cost is:

$$C_{YR} = \frac{10}{100} \times [147,000 + 1,000 + 21,000 \times (1 + 0.1 + 0.2 + 0.2 + 0.3 + 1)] \times (1 + 0.15)$$

$$C_{YR} = 0.1 \times [148,000 + 21,000 \times (2.8)] \times 1.15$$

$$C_{YR} = \$23,800$$

The new system cost calculation parallels that for the rework cost, except that the rework factor (F_{YR}) is not included. For our example, the cost of the new leak detection system (C_{YN}) is:

$$C_{YN} = [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \\ \times (1 + F_{YD})$$

Using the same values as above,

$$C_{YN} = [148,000 + 21,000 \times (1 + 0.1 + 0.2 + 0.2 + 0.3)] \times 1.15$$

$$C_{YN} = \$213,700$$

In the absence of other related costs, the total cost for the system modification at the reference plant (C_{YT}) is the sum of the rework cost and the new system cost:

$$C_{YT} = C_{YR} + C_{YN} = 23,800 + 213,700$$

$$C_{YT} = \$237,500$$

Note that a plant well along in construction, but prior to fuel loading, would have no significant radiation to contend with and therefore the radiation productivity factor (F_{LR}) would be zero.

Worksheets 5.2 and 5.3 can be used to calculate the costs for plants under construction and operating, respectively.

5.4 CAVEATS

- The user is reminded that the approach presented here provides a gross representation of the costs associated with retrofitting and reworking systems at existing plants. The cost factors included here are intended to address the most common problems that tend to drive retrofitting costs. The user should be alert to particular circumstances of the plant being evaluated and to other cost factors not addressed here.
- Indirect costs incurred to support engineering and construction activities, e.g., management, support services, cleanup, etc., have not been included in this approach. Where these costs could be significant, a cost factor as a percentage of direct cost could be estimated and included.

WORKSHEET 5.2 Costs for Plants under Construction

Requirement Name:

Reference Plant Name:

Reference Plant System/Component:

Analogous Data Base System/Component:

Regional Prorated Data Base Cost (from Worksheet 5.1):

Equipment (C_{EP}):

Materials (C_{MP}'):

Labor (C_{LP}'):

- System Rework Cost (C_{YR})

$$= P_{YR} \times [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{YR} + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{YD})$$

- New System Work Cost (C_{YN})

$$= [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{YD})$$

- Other Related Costs (identify):

$$\text{Total System Cost } (C_{YT}) = C_{YR} + C_{YN} + (\text{Other Related Costs})$$

WORKSHEET 5.3 Costs for Operating Plants

Requirement Name:

Reference Plant Name:

Reference Plant System/Component:

Analogous Data Base System/Component:

Regional Prorated Data Base Cost (from Worksheet 5.1):

Equipment (C_{EP}):

Materials (C_{MP}'):

Labor (C_{LP}'):

- Systems Rework Cost (C_{YR})

$$= P_{YR} \times [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{YR} + F_{LC} + F_{LR} + F_{LA} + F_{LM})] \times (1 + F_{YD})$$

- New System Work Cost (C_{YN})

$$= [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{LC} + F_{LR} + F_{LA} + F_{LM})] \times (1 + F_{YD})$$

- Other Related Costs (identify):

$$\text{Total System Cost } (C_{YT}) = C_{YR} + C_{YN} + (\text{Other Related Costs})$$

6 UTILITY-RELATED COSTS

This section deals with the activities and their costs that are normally the direct responsibility of the affected plants' licensees. The two major areas of costs addressed here are the costs associated with changes in plant personnel and their qualifications, and the costs associated with resolving generic regulatory actions on a plant-specific basis, including the costs of revising licensing documents.

6.1 PERSONNEL COSTS

Regulatory requirements can affect the costs for plant operating and maintenance (O&M) personnel and support personnel in two major ways: (1) by significantly changing the number of personnel needed to operate and maintain the plant and (2) by changing the training and/or qualification requirements for such personnel.

Most nuclear generating stations maintain six full operating crews for each unit. Therefore, if a new, permanently manned operating position is created as a result of a requirement, six new full-time operators must be hired. Salaries for operating and support personnel vary widely around the country. The following rates have been suggested, by a nuclear utility believed to be reasonably representative of the industry as a whole, as typical for the categories indicated. However, for the purposes of estimating the cost for a generic requirement, a value of 1.5 times the rate shown below is recommended to account for overhead and general and administrative expenses.

Personnel Category	Rate (R _p)*	
	\$/hr	\$/yr
Operating and Maintenance	25	53K
Engineering	28	60K
Management	30	63K

Fractional changes in numbers of plant personnel can be costed on a pro-rated basis from these rates. Note that costs associated with permanent changes to the operating or support staff continue to accrue over the remaining plant lifetime, and therefore are evaluated over that period and discounted back to the present using the annuity formula.

A separate but significant cost for operating personnel at a nuclear plant is that for training. The following are typical reactor operator training costs for central station BWR and PWR plants.

*These represent fully loaded costs, expressed in 1984 dollars, including all fringe benefits, but not including overhead and general and administrative expenses.

Training Type	Cost (1985 \$)	
	BWR	PWR
Initial training resulting in reactor license* (C_{TI})	55K	70K
Annual update training (R_{TA})	13K/yr	16K/yr

Initial and update training for a Senior Reactor Operator will typically cost 1.5 times that for a regular licensed operator. Training for auxiliary plant, electrical plant, and turbine plant operators will cost somewhat less than that for reactor operators. In the absence of specific cost information, a factor of 0.5 times the cost for training a reactor operator can be used to estimate the training cost for other operators.

Worksheet 6.1 provides the formulas for calculating estimated costs for changes to the utility staff personnel for the reference plant. Worksheet 6.2 can be used to calculate the estimated costs for licensing changes and for the total direct cost to the utility for the reference plant as a result of the requirement.

6.2 LICENSING AND TECHNICAL SUPPORT COSTS

Other significant areas of cost to the utility related to regulatory changes are the costs to resolve generic regulatory issues for each of the specific plants affected. Included are such costs as formulating plant-specific changes, preparing revisions to licensing documents, changing in-house procedures, conducting technical analyses, and revising and conducting new training sessions. For example, the cost to a utility to develop and implement a change to a technical specification has been estimated (by a nuclear utility believed to be representative of the industry as a whole) at \$16K to \$32K. The lower value represents the cost of an uncomplicated change, while the high value represents the cost for a complex and controversial change. In the absence of other cost data on other types of licensing changes, these values can be used to compare the cost to the utility for all major licensing changes. A judgment must be made about the degree of complexity of the change and the use of the higher or lower value or some intermediate value. Note that the above costs do not include any major technical analyses that may have to be performed in support of a licensing change. This cost must be evaluated separately and may very well dominate the licensing costs. For example, a new loss-of-coolant accident analysis could easily cost \$100K.

*Assumes a general technical background at the engineering associate level.

WORKSHEET 6.1 Utility Personnel Costs**Requirement Name:****Reference Plant Name:****Personnel Costs:**

- Annual Personnel Cost (C_{PA})* = $N \times R_P$
where N = Number of permanent full-time positions added in a particular staff category.[‡]
- Total Annual Personnel Cost (C_{PAT}) = $C_{PA_1} + C_{PA_2} + \dots$
- Lifetime Personnel Cost (C_{PL}) = $C_{PAT} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]$

Training Costs:

- Total Initial Training Cost (C_{TIT}) = $N_1 \times C_{TI_1} + N_2 \times C_{TI_2} + \dots$
- Annual Training Cost (C_{TA})* = $N \times R_{TA}$
- Total Annual Training Cost (C_{TAT}) = $C_{TA_1} + C_{TA_2} + \dots$
- Lifetime Training Cost (C_{TL}) = $C_{TIT} + C_{TAT} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]$

$$\text{Total Lifetime Cost for Personnel } (C_{TP}) = C_{PL} + C_{TL}$$

*To be evaluated for each category of staff personnel affected.

‡It may be appropriate to assign fractional values for personnel to represent a part-time attribution of a new position to the requirement being evaluated.

WORKSHEET 6.2 Licensing and Total Utility Costs**Requirement Name:****Reference Plant Name:****Major Licensing Document Change Necessary?**If yes, estimated total cost for such change (C_{LD}) =**Major Technical Analyses Required?**If yes, estimated total cost for such analyses (C_A) =**Total Utility Licensing Cost (C_{UL}) = $C_{LD} + C_A$** **Total Utility Cost for Requirement (C_{UT}) = $C_{UL} + C_{TP}$**

7 COSTS TO THE NUCLEAR REGULATORY COMMISSION AND OTHER GOVERNMENT AGENCIES

The NRC will incur certain costs in developing and implementing generic regulatory requirements. Although these costs, by the nature of the regulatory process, are fully recoverable through the licensing fee structure and are ultimately borne by the licensee, they will be discussed and accounted for in the context of a regulatory cost. The major activities conducted by the NRC with regard to generic requirements are (1) developing a generic issue into its final form as a multiplant action, (2) implementing the generic action for each of the affected plants, and (3) monitoring the operation of the requirement at each plant.

Other federal, state, and local government agencies can also incur costs as a result of a regulatory requirement. Again, these costs are usually recovered from the licensee through fees or other forms of payment. These costs will be discussed only qualitatively.

7.1 NRC DEVELOPMENT COSTS

In-house NRC cost tracking has shown that, on the average, the equivalent of about 1.7 person-years of professional effort are needed to fully develop a generic safety issue from prioritization until a technical resolution is approved by the Committee to Review Generic Requirements (CRGR), including both NRC staff effort and supporting contract work. At approximately \$122K per fully loaded NRC staff-year and \$135K per person-year of contract work, this average cost is about \$217K (1985 figures). Costs of relatively simple and relatively complex projects may vary several-fold from this average. Because this is a one-time cost for the generic requirement, it is likely to be only a small fraction of the overall estimate.

7.2 NRC IMPLEMENTATION COSTS

Each generic action must be implemented on a plant-by-plant basis. Implementation involves meetings with the licensee to work out a satisfactory technical resolution, reviewing changes to licensing documents, reviewing technical analyses by others, and conducting independent analyses. Average NRC costs have been calculated for various types of multiplant actions based on actual in-house charges in the implementation of past actions.¹¹ Table 7.1 summarizes the average costs for some categories of NRC actions.

7.3 NRC INSPECTION AND ENFORCEMENT COSTS

These costs are associated with inspection and enforcement activities (I&E) required after imposition of a requirement. Depending on the nature of the requirement, this could be a one-time cost or a recurring cost if the requirement calls for periodic inspections and/or tests. No specific data exist on the I&E costs associated with various

TABLE 7.1 Summary of Average NRC-Related Costs

Action categories	Technical Effort per Plant	
	Staff Hours ^a	Cost (10 ³) ^b
Multiplant Actions		
Series A-E & G	175	14
MPA Series F (NUREG-0737)	70	6
Reload Methods	485	38
Reload Reviews	210	16
Technical Specifications (uncomplicated) ^c	--	13
Technical Specification (complicated)	--	25

^aStaff hours based on technical effort only.

^bCost based on 1729 hours/staff-year and a fully loaded technical staff rate of \$135K/staff-year (1986 dollars).

^cThese costs have been extracted from Ref. 3.

types of requirements. However, average salary rates are available in 1984 dollars for both home office I&E staff and regional office staff. These are \$46K and \$40K per year, respectively. A reasonable charge rate for these two positions, including benefits, M&S, allowance for clerical and management support, and overhead, would be twice the salary rate, or \$92K (\$348/staff-day) and \$80K (\$303/staff-day), respectively. One or more types of inspectors might be necessary, depending on the licensee activities affected by the requirement. For each man-day of additional direct inspection required, the following factors should be multiplied by the daily charge rate. The factors account for the indirect costs to be applied to each day of direct effort, e.g., pre-inspection preparation and post-inspection documentation and related travel.

Senior Resident Inspector	2.27
Resident Inspector	1.89
Project Inspector	5.00
Other Specialized Inspector (Radiological safety, safe- guards, reactor engineering, emergency preparedness)	3.13

The user should consult with the Office of Inspection and Enforcement (I&E) (the Division of Emergency Preparedness and Engineering Response will be the lead and will coordinate with other divisions to provide a consolidated response) to determine which specific actions will warrant inspection. The major criteria depend on the safety significance of the item and the resources needed to accomplish the inspection. The user should then estimate the effects, if any, on the additional staff-days of inspection as a result of the requirement and estimate their costs based on the daily charge rates. The user should be aware that additional I&E personnel could be required both during installation of the plant modification(s) and on a continuing basis during plant operation. The first would constitute a one-time cost, while the latter would be a recurring cost. Worksheet 7.1 can be used to calculate the estimated cost for implementation and for inspection and enforcement.

7.4 OTHER GOVERNMENT COSTS

The user should be aware that other federal, state, and local government agencies could be affected by an NRC requirement. Examples might include the need for new environmental assessment work on the part of the EPA, changes in the station emergency plan involving state and local officials, and changes in the station's effluents that require new effluent release permits. No generic cost information is available for this guide, but the user should be aware of these potential costs and estimate them case by case.

WORKSHEET 7.1 NRC Costs for Implementation, Inspection, and Enforcement**Requirement Name:****Reference Plant Name:****Implementation Costs:**

- Category of Multiplant Action Representing the Requirement:
- Estimated Implementation Cost (C_I):

I&E Costs:

- Estimated Change in I&E Personnel for Installation of Modification (I_P) = staff-days
- Charge Rate for I&E Personnel (C_{IP}) (\$350/staff-day or \$300/staff-day) = \$/staff-day
- Total Cost for I&E during Installation (C_{II}) = $I_P \times C_{IP}$
- Change in I&E Personnel* Permanently Assigned to the Reference Plant (N_I):
- Annual I&E Cost (C_{IA}) = $N_I \times 80K$
- Lifetime I&E Costs (C_{IL}) = $C_{II} + C_{IA} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]$

Total NRC Cost for Reference Plant (C_{NRC}) = $C_I + C_{IL}$

*It may be appropriate to assign fractional values to I&E personnel assigned to the reference plant.

8 AGGREGATING COSTS

Each of the eight major cost categories identified in Chapter 1 have now been addressed in the context of estimating their cost for a reference plant that represents a group of plants of like characteristics. The remaining tasks in assembling an estimate of the total national lifetime cost of a generic requirement are (1) aggregating the cost categories for the reference plant(s), (2) aggregating the costs for all plants in a particular group, (3) aggregating the costs for all groups of plants, and (4) adding in the generic costs to complete the estimate.

8.1 AGGREGATING THE REFERENCE PLANT COSTS

Before adding up the estimated costs for the various cost categories, the user must ensure that all one-time costs are expressed in present-worth dollars and that all future periodic costs have been discounted back to the present and are expressed as lump-sum, present-worth costs. The methods presented in the worksheets for the various cost categories includes the appropriate expressions for calculating present-worth, lump-sum costs. For those costs that may not be expressed in current-year dollars, an adjustment should be made at this time to those costs to express them in present-worth dollars. This can be done through the formula:

$$F_C = C(1 + i)^n$$

where:

C = cost expressed in past year's dollars,

F_C = cost expressed in the future year's dollars,

i = inflation rate as a decimal,

n = number of years between the future year and the past year.

The Nuclear Energy Cost Data Base¹² provides guidance for selecting an appropriate value for i to analyze nuclear power plant costs.

Once all the reference plant cost categories are expressed in the current year's dollars, the total reference plant cost is simply the algebraic sum of the appropriate cost categories. Worksheet 8.1 will aid in identifying and aggregating all appropriate costs for the reference plant and the group of plants. As pointed out earlier, some costs could be negative, representing a cost savings for a particular category as a result of the requirement. Therefore, in cost accounting, this negative cost would somewhat offset the other positive costs. The periodic costs have previously been evaluated on a present-value lump sum basis and it is therefore appropriate to add these costs to the capital costs. Note also that those costs that represent fixed costs to utilities, the NRC, or

WORKSHEET 8.1 Aggregation of Costs for a Common Group of Plants**Requirement Name:****Reference Plant Name:****Reference Plant Costs:** (year of estimate)

<u>Cost Category</u>	<u>Plant Costs</u> <u>Year-dollars</u>	<u>Generic Costs</u> <u>(specify)</u>
Replacement Energy		
Structures (including engineering and QA)		
Systems (including engineering and QA)		
Plant Personnel		
Utility Licensing and Administration		
NRC		
Other Government		
Total Plant-Specific Cost		
Total Generic (fixed) Cost		

Number of Plants in Group:

Total Cost for All Plants in Group = Total Plant-Specific Cost x Number of
Plants + Total Generic Cost

other government agencies in the implementation of the requirement are not included in the reference plant costs but are accounted for separately and added to the total plant specific cost for the group of plants.

By definition, the reference plant cost represents the cost of implementing the generic requirement at each of the plants in the group from which the reference plant was chosen. Therefore, it is appropriate to multiply the reference plant total cost by the number of plants in that particular group to arrive at a total cost for all affected plants in the group.

8.2 CALCULATING TOTAL NATIONAL LIFETIME COST

As pointed out in Chapter 2, more than one group of plants may be needed in order to properly characterize all of the plants affected by the requirement. In this case, a reference plant will have been defined for each group and a separate cost estimate made for each reference plant. The procedure for evaluating the total estimated cost for a group of plants, as described in Sec. 8.1, should be performed for each group. The final steps in evaluating the total national lifetime cost of the requirement is to add up the costs for all of groups of plants affected by the requirement (all affected plants should now be accounted for) and finally to add in any fixed NRC costs related to the requirement as a whole. Worksheet 8.2 can be used to evaluate and document the total cost of the requirement.

WORKSHEET 8.2 Evaluation of Total National Lifetime Cost**Requirement Name:****Plant Group Costs:**

<u>Reference Plant Name</u>	<u>Total Group Cost (from Worksheet 8.1) Year-dollars (specify)</u>
-----------------------------	---

1.

2.

3.

4.

 Total Cost for All Groups

Fixed NRC Costs

Total National Lifetime Cost:

9 EXAMPLE OF COST ESTIMATE

This chapter presents a sample estimate using the method and cost data in this handbook to illustrate the use of the handbook with actual numbers. The requirement selected for analysis is the same as that used in the original handbook, namely the Technical Support Center (TSC) requirement promulgated in NUREG-0696. Thus, the results can be compared with the more comprehensive estimating method developed in the original handbook.

The technical requirements and assumptions used to estimate the TSC cost in the handbook are also used here for consistency. All 108 plants are assumed to be affected. As in the original handbook, it is assumed that 50% of the plants will build a new structure to house the TSC, while the other 50% will use an existing structure of comparable design. Therefore, two reference plants will be used, each representing 50% of the plants. The only cost category where this assumption is significant is in evaluating the structures cost. For reference plant 1 (Sample Unit 1), a structure utilization cost is calculated, while for Sample Unit 2, the cost of designing and building a new structure is estimated. The remaining cost categories are the same for both reference plants and therefore are evaluated as a single case. The presentation of the example estimate is in the form of a package of all of the appropriate data sheets and worksheets filled out for the TSC requirement. The user should study these example sheets, along with the definitions for the technical and cost parameters from the preceding chapters to understand how the methods and data have been used to estimate total cost.

Several observations can be made about the results of this example estimate:

- When assembled, the filled-in data sheets and worksheets make up a complete documentation package of the cost estimate.
- For each of the sample reference plants, only the structures, systems, design, and QA categories are significant to the total cost. The other categories combined represent only <5% of the total cost and therefore could have been neglected.
- The total reference plant cost is within 30% of the more detailed estimate found in the original handbook.
- Given that the example used here is applied to only 108 plants, whereas the original example is applied to 140 plants, the total national lifetime estimates are quite consistent.
- The NRC's Office of Nuclear Reactor Regulation sponsored an analysis of the actual costs for constructing technical support centers at various plants.¹³ These costs were shown to range from \$0.8 to \$4.0 million for the structure and equipment. The sample estimate performed here yields values of \$2.6 and \$2.9 million, depending on whether an existing structure was used or a new structure was built.

DATA SHEET 2.1 NRC Generic Requirement

Requirement Name: Technical Support Center (ref: NUREG-0737)

Current Status of Requirement

(generic safety issue, fully developed, etc.): Fully developed.

Ultimate Form Anticipated

(Reg. Guide, 10 CFR 50 change, MPA, etc.): MPA-TMI Action Item.

Provisions:

Categories of plants affected (PWR, BWR, NSSS supplier, operating under construction, etc.): All plants affected.

Physical plant changes: Construction and outfitting of a technical support center.

Technical analyses: None required.

Plant staff changes: No new staff anticipated. Present staff training anticipated.

Time frame for implementation (immediate shutdown required, long-term implementation, etc.): Long-term.

DATA SHEET 2.2 Specific Plant Characteristics

Essential Characteristics

Plant Name: Sample Unit 1

Utility: NA

Location: NE United States

Type: PWR

Net Capacity (kW_e): NA

NSS Supplier: NA

Architect-Engineer: NA

Status (% Complete): Operating

Technical Features (typical)

Containment Type: NA

Ultimate Heat Sink: NA

Reference Plant Grouping: Reference Group 1. Construct a completely new facility on the station site to house the technical support center.

DATA SHEET 2.2 Specific Plant Characteristics

Essential Characteristics

Plant Name: Sample Unit 2

Utility: NA

Location: NE United States

Type: PWR

Net Capacity (kW_e): NA

NSS Supplier: NA

Architect-Engineer: NA

Status (% Complete): Operating

Technical Features (typical)

Containment Type: NA

Ultimate Heat Sink: NA

Reference Plant Grouping: Reference Group 2. Utilize existing structures to house the technical support center.

DATA SHEET 3.1 Replacement Energy Cost

Requirement Name: Technical Support Center

Plant Name: NA -- no replacement energy costs anticipated.

NERC Region:

Reference Plant Name:

Type of Plant (BWR or PWR):

Net Electrical Output - E (kW_e):

Change in Net Electrical Output - E_C (kW_e):

Percent Power Reduction - Q (%):

Percent Change in Capacity Factor - P_F (%):

Shutdown Period - P (hr):

Reduced Power Period - T (hr):

Replacement Energy Charge Rate - R (\$/kWh, 1985):

Multiplant Factor - M :

Remaining Plant Operating Life - L (yr):

Discount Rate - D :

DATA SHEET 4.1 Technical and Cost Data for Plant Structures

Requirement Name: Technical Support Center (ref. NUREG-0737)

Reference Plants

Plant Name: Sample Units 1 & 2

Percent Complete: Operating

Structure Name: Technical Support Center as an addition

Seismic Classification: Non-Seismic

Special Features: None

Volume Requirements - V_R (ft³): 60,000

Existing Volume Utilization - V_E (ft³): 60,000

Rework Volume - V_{RE} (ft³): NA

Addition Volume - V_{AD} (ft³): NA

Data Base Plant

Analogous Structure Name: Technical Support Center as constructed

Seismic Classification: Non-Seismic

Structural Composition:

Volume of Analogous Structure - V_A (ft³): 60,000

Volume Utilization Cost - C_{VU} (\$/ft³): 10.3

Analogous Structure Costs: (1983 \$)

EEDB Account No.: 218L

Equipment (C_E): 60K

Materials (C_M): 202K

Labor (C_L): 423K

Engineering and QA Cost Factor for Analogous Structure - F_{SD} (%): 15 (Assumed)

Cost Factors

Congestion Productivity Factor - F_{LC} : 0.2

Radiation Productivity Factor - F_{LR} : 0.0

Access Productivity Factor - F_{LA} : 0.2

Manageability Productivity Factor - F_{LM} : -0.2

Regional Materials Cost Factor - F_M : 0.95

Regional Labor Cost Factor - F_L : 0.91

Structural Rework Cost Factor - F_{SR} : NA

WORKSHEET 4.3 New Structures Costs

Requirement Name: Technical Support Center

Reference Plant Name: Sample Unit 1

Analogous Data Base Structure: TSC

Cost of Data Base Structure: Equipment (C_E): 60K
 Materials (C_M): 202K
 Labor (C_L): 423K

Regional Cost Adjustments:

$$C_M' = C_M \times F_M \quad 202 (0.95) = \$192K$$

$$C_L' = C_L \times F_L \quad 423 (0.91) = \$385K$$

New Structure Cost (C_{ST}):

$$= \frac{V_R}{V_A} \times [C_E + C_M' + C_L' \times (1 + F_{LR} + F_{LC} + F_{LA} + F_{LM})] \times (1 + F_{SD})$$

$$= \frac{60}{60} \times (60 + 192 + 385 \times (1.0 + 0.2 + 0.2 - 0.2)) \times (1 + 0.15) = \$821K$$

Adjustment to 1984 dollars:

$$F_C = C (1 + i)^n$$

$$i = 0.07$$

$$n = 1$$

$$F_C = 821(1.07) = \$879K$$

DATA SHEET 5.1 Technical and Cost Data for Plant Systems

Requirement Name: Technical Support Center

Technical and Cost Data

Reference Plant

Plant Name: Sample Units 1 & 2

Percent Complete: Operating

System Name: TMI Instrumentation

Safety Class: NN

Equipment/Component Description

Percentage of Existing System Rework - P_{YR} : 0

Data Base Plant

Analogous System/Component Name: TMI Instrumentation

Safety Class: NN

Percentage of System/Subsystem Cost - P_Y : 33

Analogous System Costs: (1983 \$)

EEDB Account No.: 227.9

Equipment (C_E): \$2,167K Materials - C_M : \$25K

Labor (C_L): \$1,332K

Engineering and QA/QC Cost Factor for Analogous System (F_{YD}): 15 (Assumed)

Cost Factors

Congestion Productivity Factor - F_{LC} : 0.2

Radiation Productivity Factor - F_{LR} : 0.0

Access Productivity Factor - F_{LA} : 0.2

Manageability Productivity Factor - F_{LM} : (-0.2)

Regional Materials Cost Factor - F_M : 0.97

Regional Labor Cost Factor - F_L : 0.95

Systems Rework Cost Factor - F_{YR} : NA

WORKSHEET 5.1 Costs for New Plants

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Reference Plant System/Component: TMI Instrumentation

Analogous Data Base System: TMI Instrumentation

Cost of Data Base System/Component: Equipment (C_E): \$2,167K
 Materials (C_M): \$25K
 Labor (C_L): \$1,332K

Prorated Costs: (C_{EP}) = $C_E \times P_Y$, (C_{MP}) = $C_M \times P_Y$, (C_{LP}) = $C_L \times P_Y$

$$(\mathbf{C_{EP}}) = 2167 \times 0.33, (\mathbf{C_{MP}}) = 25 \times 0.33, (\mathbf{C_{LP}}) = 1,332 \times 0.33$$

- Prorated Cost of Data Base System/Component Applied to Reference Case:

Equipment (C_{EP}): \$715K

Materials (C_{MP}): \$8K

Labor (C_{LP}): \$440K

- Regional Cost Adjustments:

$$C_{MP}' = C_{MP} \times F_M \quad 8 \times 0.97 = \$7.8K$$

$$C_{LP}' = C_{LP} \times F_L \quad 440 \times 0.95 = \$418K$$

$$\mathbf{Base\ System\ Cost\ (C_{YB}) = C_{EP} + C_{MP}' + C_{LP}' = 715 + 7.8 + 418 = 1,141K}$$

- Base System Engineering and QA Cost (C_{YBD})

$$= C_{YB} \times \frac{F_{YD}}{100} = 1,141 \times \left(\frac{15}{100}\right) = \$171K$$

$$\mathbf{Total\ System\ Cost\ (C_{YT}) = C_{YB} + C_{YBD} = 1141 + 171 = \$1,312K}$$

WORKSHEET 5.3 Costs for Operating Plants

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Reference Plant System/Component: TMI Instrumentation

Analogous Data Base System/Component: TMI Instrumentation

Regional Prorated Data Base Cost (from Worksheet 5.1):

Equipment (C_{EP}): \$715K

Materials (C_{MP}'): \$8K

Labor (C_{LP}'): \$418K

- Systems Rework Cost (C_{YR})

$$= \frac{P_{YR}}{100} \times [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{YR} \times F_{LC} \times F_{LR} \times F_{LA} \times F_{LM})] \times (1 + F_{YD})$$

- New System Work Cost (C_{YN})

$$= [C_{EP}' + C_{MP}' + C_{LP}' \times (1 + F_{LC} + F_{LR} + F_{LA} + F_{LM} + F_{LQ})] \\ + F_{LA} + F_{LM} + F_{LQ} \times (1 + F_{YD}) \\ = 715 + 8 + 419 \times (1 + 0.2 + 0 + 0.2 - 0.2)] \\ \times (1 + 0.15) = \$1410K$$

- Other Related Costs (identify): None

Total System Cost (C_{YT}) = $C_{YR} + C_{CN} + (\text{Related Costs}) = \$1,410K$

Adjustment to 1984 Dollars = $1,410 \times 1.07 = \$1,508K$

DATA SHEET 5.1 Technical and Cost Data for Plant Systems

Requirement Name: Technical Support Center

Technical and Cost Data

Reference Plant

Plant Name: Sample Units 1 & 2

Percent Complete: Operating

System Name: TSC System Control Panels

Safety Class: NN

Equipment/Component Description:

Percentage of Existing System Rework - P_{YR} : 0

Data Base Plant

Analogous System/Component Name: TSC System Control Panels

Safety Class: NN

Percent of System/Subsystem Cost - P (%): 50

Analogous System Costs: (1983 \$)

EEDB Account No.: 243.15

Equipment (C_E): \$597K

Materials (C_M): \$13K

Labor (C_L): \$43K

Engineering and QA/QC Cost Factor for Analogous System - F_{YD} (%): 15 (assumed)

Cost Factors

Congestion Productivity Factor - F_{LC} : 0.2

Radiation Productivity Factor - F_{LR} : 0.0

Access Productivity Factor - F_{LA} : 0.2

Manageability Productivity Factor - F_{LM} : (-0.2)

Regional Materials Cost Factor - F_M : 0.97

Regional Labor Cost Factor - F_L : 0.95

Systems Rework Cost Factor - F_{YR} : NA

WORKSHEET 5.1 Costs for New Plants

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Reference Plant System/Component: TSC System Control Panels

Analogous Data Base System: TSC System Control Panels

Cost of Data Base System/Component:

Equipment (C_E): \$597K

Materials (C_M): \$13K

Labor (C_L): \$43K

Prorated Costs: (C_{EP}) = $C_E \times P_Y$, (C_{MP}) = $C_M \times P_Y$, (C_{LP}) = $C_L \times P_Y$

$$C_{EP} = 597 \times 0.5, C_{MP} = 13 \times 0.5, C_{LP} = 43 \times 0.5$$

- Prorated Cost of Data Base System/Component Applied to Reference Case:

Equipment	Materials	Labor
(C_{EP}) = \$299K	(C_{MP}) = \$6.5K	(C_{LP}) = \$21.5K

- Regional Cost Adjustments:

$$C_{MP}' = C_{MP} \times F_M \quad 6.5 \times 0.97 = \$6.3K$$

$$C_{LP}' = C_{LP} \times F_L \quad 21.5 \times 0.95 = \$20.4K$$

Base System Cost (C_{YB}) = $C_{EP} + C_{MP}' + C_{LP}' = 299 + 6.3 + 20.4 = \$325K$

- Base System Engineering and QA Cost (C_{YB}) = $C_{YB} \times \frac{F_{YD}}{100} = 325 \times \frac{15}{100} = \$49K$

Total System Cost (C_{YT}) = $C_{YB} + C_{YBD} = 325 + 49 = \$374K$

WORKSHEET 5.3 Costs for Operating Plants

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Reference Plant System/Component: TSC System Control Panel

Analogous Data Base System/Component: TSC System Control Panel

Regional Prorated Data Base Cost (from Worksheet 5.1):

Equipment (C_{EP}): \$299K

Materials (C_{MP}'): \$6.3K

Labor (C_{LP}'): \$20.4K

- System Rework Cost (C_{YR})

$$= [C_{EP} + C_{MP}' + C_{LP}' \times (1 + F_{YR} + F_{LC} + F_{LR} + F_{LA} + F_{LM})] \times (1 + F_{YD})$$

- New System Work Cost (C_{YN}):

$$= [C_{EP} + C_{MP}' + C_{LP}' \times (F_{LC} + F_{LR} + F_{LA} + F_{LM})] \times (1 + F_{YD}) = 299 + 6.3 + 20.4 \times (1 + 0.2 + 0 + 0.2 - 0.2) \times (1 + 0.15) = \$379K$$

- Other Related Costs (identify): None

Total System Cost (C_{YN}) = C_{YR} + C_{YN} + (Related Costs) = \$379K

Adjustment to 1984 Dollars: $379 \times (1.07) = \$405K$

WORKSHEET 6.1 Utility Personnel Costs**Requirement Name:** Technical Support Center**Reference Plant Name:** Sample Units 1 & 2**Personnel Costs**

- Annual Personnel Cost (C_{PA})* = $N \times R_P$

where N = Number of permanent full-time positions added in a particular staff category.[†]

- Total Annual Personnel Cost (C_{PAT}) = $C_{PA_1} + C_{PA_2} + \dots$

- Lifetime Personnel Cost (C_{PL}) = $C_{PAT} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]$

Training Costs:

- Total Initial Training Cost (C_{TIT}) = $N_1 \times C_{TI_1} + N_2 \times C_{TI_2} + \dots$
 $= 10 \times 1 + 20 \times 0.5K = \$20K$

- Annual Training Cost (C_{TA})* = $N \times R_{TA}$

- Total Annual Training Cost (C_{TAT}) = $C_{TA_1} + C_{TA_2} + \dots = 3 + 5 = \$8K$

$$\text{Lifetime Training Cost } (C_{TL}) = C_{TIT} + C_{TAT} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right]$$

$$= 20K + 8K \left[\frac{(1 + 0.1)^{20} - 1}{0.1(1 + 0.1)^{20}} \right]$$

$$= 20K + 68K = \$88K$$

$$\text{Total Lifetime Cost for Personnel } (C_{TP}) = C_{PL} + C_{TL} = \$88K$$

*To be evaluated for each category of staff personnel affected.

[†]It may be appropriate to assign fractional values for personnel to represent a part-time attribution of a new position to the requirement being evaluated.

WORKSHEET 6.2 Licensing and Total Utility Costs

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Major Licensing Document Change Necessary? ☒ yes ☐ no

If yes: estimated total cost for such change (C_{LD}) = \$16K

Major Technical Analyses Required? ☐ yes ☒ no

If yes: estimated total cost for such analyses (C_A) =

Total Utility Licensing Cost (C_{UL}) = $C_{LD} + C_A$ = \$16K

Total Utility Cost for Requirement (C_{UT}) = $C_{UL} + C_{TP}$ = 16K + 88K = \$104K

WORKSHEET 7.1 NRC Costs for Implementation, Inspection, and Enforcement

Requirement Name: Technical Support Center

Reference Plant Name: Sample Units 1 & 2

Implementation Costs:

- Category of Multiplant Action Representing the Requirement:
NUREG-0737
- Estimated Implementation Cost (C_I) = \$6K (1986 dollars)

I&E Costs:

- Estimated Change in I&E Personnel for Installation of Modification (I_P) = 30 staff-days
- Charge rate for I&E Personnel (C_{IP}) = \$300/staff-day
(\$350/staff-day or \$300/staff-day)
- Total Cost for I&E during Installation (C_{II}) = $I_P \times C_{IP} = 30 (300)$
= \$9K (1986 dollars)
- Change in I&E Personnel* Permanently Assigned to the Reference Plant (N_I) = None
- Annual I&E Cost (C_{IA}) = $N_I \times 80K = 0$
- Lifetime I&E Costs (C_{IL}) = $C_{II} + C_{IA} \times \left[\frac{(1 + D)^L - 1}{D(1 + D)^L} \right] = \$9K$

Total NRC Cost for Reference Plant (C_{NRC}) = $C_I + C_{IL} = 6 + 9 = \$15K$

Adjustment to 1984 dollars: $w \frac{C_{NRC}}{(1 + i)^n} = \frac{15K}{(1 + 0.07)^2} = \$13K$

*It may be appropriate to assign fractional values (1985 dollars) to I&E personnel assigned to the reference plant.

WORKSHEET 8.1 Aggregation of Costs for a Common Group of Plants**Requirement Name:** Technical Support Center**Reference Plant Name:** Sample Unit 1**Reference Plant Costs:** (year of estimate - 1984)

Cost Category	Plant Costs 1984 Year-dollars (1984)	Generic Costs
Replacement Energy	0	
Structures (including engineering and QA)	879K	
Systems (including engineering and QA)	1913K	
Plant Personnel	88K	
Utility Licensing and Administration	16K	
NRC	13K	
Other Government	---	
Total Plant-Specific Cost	\$2909K	0
Total Generic (fixed) Cost		

Number of Plants in Group: 54

Total Cost for All Plants in Group = Total Plant-Specific Cost x Number of
Plants + Total Generic Cost

$$\$2909K \times 54 = \$157 \text{ Million}$$

WORKSHEET 8.1 Aggregation of Costs for a Common Group of Plants**Requirement Name:** Technical Support Center**Reference Plant Name:** Sample Unit 2**Reference Plant Costs:** (year of estimate - 1984)

Cost Category	Plant Costs 1984 Year-dollars	Generic Costs (1984)
Replacement Energy	0	
Structures (including engineering and QA)	614K	
Systems (including engineering and QA)	1913K	
Plant Personnel	88K	
Utility Licensing and Administration	16K	
NRC	13K	
Other Government	---	
Total Plant-Specific Cost	\$2644K	0
Total Generic (fixed) Cost		

Number of Plants in Group: 54

Total Cost for All Plants in Group = Total Plant-Specific Cost x Number of
Plants + Total Generic Cost

$$\$2644K \times 54 = \$143 \text{ Million}$$

WORKSHEET 8.2 Evaluation of Total National Lifetime Costs**Requirement Name:** Technical Support Center**Plant Group Costs:**

Reference Plant Name	Total Group Cost - From Worksheets 8.1 (Year-dollars)
1. Sample Unit 1	\$157 Million
2. Sample Unit 2	\$143 Million
3. -	
4. -	
<hr/>	
Total Cost for All Groups	\$300 Million
Fixed NRC Costs	\$230K
	(Negligible)
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Total National Lifetime Cost	\$300 Million

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APPENDIX A:
SYMBOLS AND DEFINITIONS
USED IN THIS REPORT

APPENDIX A:
SYMBOLS AND DEFINITIONS
USED IN THIS REPORT

SYMBOL	DEFINITION
C	Past Cost
C _A	Cost for Technical Analyses (\$)
C _E	Equipment Cost (\$)
C _E '	Regional Equipment Cost (\$)
C _{EP}	Prorated Equipment Cost (\$)
C _I	Estimated Implementation Cost (\$)
C _{IA}	Annual I&E Cost (\$)
C _{II}	Total Cost for I&E during Installation (\$)
C _{IL}	Lifetime I&E Cost (\$)
C _{IP}	Charge Rate for I&E Personnel (\$/man-day)
C _L	Labor Cost (\$)
C _L '	Regional Labor Cost (\$)
C _{LD}	Cost for Document Change (\$)
C _{LP}	Prorated Labor Cost (\$)
C _{LP} '	Regional Prorated Labor Cost (\$)
C _M	Materials Cost (\$)
C _M '	Regional Materials Cost (\$)
C _{MP}	Prorated Materials Cost (\$)
C _{MP} '	Regional Prorated Materials Cost (\$)
C _{NRC}	Total NRC Cost (\$)
C _{PA}	Annual Personnel Cost (\$)
C _{PAT}	Total Annual Personnel Cost (\$)
C _{PL}	Lifetime Personnel Cost (\$)
C _{RF}	Capacity Factor Cost (\$)
C _{RI}	Change in Capacity Factor Cost (\$)
C _{RL}	Total Lifetime Replacement Energy Cost (\$)
C _{RO}	Change in Net Electrical Output Cost (\$)
C _{RP}	Reduced Power Cost (\$)
C _{RS}	Plant Shutdown Cost (\$)
C _{SA}	Structural Addition Cost (\$)

C_{SDB}	Total Data Base Cost (\$)
C_{SM}	Total Structural Modification Cost (\$)
C_{SR}	Structural Rework Cost (\$)
C_{ST}	Total New Structure Cost (\$)
C_{SU}	Structural Utilization Cost (\$)
C_{TA}	Total Annual Training Cost (\$)
C_{TAT}	Total Annual Training Cost (\$)
C_{TI}	Initial Training Cost per Staff (\$)
C_{TIT}	Total Initial Training Cost (\$)
C_{TL}	Lifetime Training Cost (\$)
C_{TP}	Total Lifetime Training Cost (\$)
C_{UL}	Total Utility Licensing Cost (\$)
C_{UT}	Total Utility Cost (\$)
C_{VU}	Volume Utilization Cost (\$/ft ³)
C_{YB}	Base System Cost (\$)
C_{YBD}	Base System Engineering and QA Cost (\$)
C_{YN}	New System Cost (\$)
C_{YR}	System Rework Cost (\$)
C_{YT}	Total System Cost (\$)
D	Discount Rate (%)
E	Net Electrical Output (kW _e)
E_C	Change in Net Electrical Output (kW _e)
F_C	Future Worth Cost (\$)
F_L	Regional Labor Cost Factor
F_{LA}	Access and Handling Factor
F_{LC}	Congestion and Interference Factor
F_{LM}	Manageability Factor
F_{LR}	Radiation Factor
F_M	Regional Materials Cost Factor
F_{SD}	Structural Engineering and QA Cost Factor
F_{SR}	Structural Rework Cost Factor
F_{YD}	Systems Engineering and QA Cost Factor (%)
F_{YR}	Systems Rework Cost Factor
i	Inflation Rate
I_p	Change in I&E Personnel for Installation of Modification
L	Remaining Plant Lifetime (yr)

M	Multiplant Factor
N	Number of Staff Positions
n	Number of Years between Present and Future
N_I	Change in Assigned I&E Personnel
P	Shutdown Period (hr)
P_F	Change in Capacity Factor (%)
P_Y	Percentage of EEDB System Cost (%)
P_{YR}	Percentage of Existing System Rework (%)
Q	Percentage of Power Reduction (%)
R	Replacement Energy Charge Rate (\$/kWh)
R_P	Staff Personnel Rate (\$/yr)
R_{TA}	Annual Training Cost Rate (\$/yr)
T	Reduced Power Period (hr)
V_A	Volume of Analogous Structure (ft ³)
V_{AD}	Addition Volume (ft ³)
V_E	Existing Volume Utilization (ft ³)
V_R	Volume of Structure Required (ft ³)
V_{RE}	Rework Volume (ft ³)

APPENDIX B:
COMMERCIAL NUCLEAR POWER ELECTRIC GENERATING
PLANTS IN THE UNITED STATES, 1985

APPENDIX B:

**COMMERCIAL NUCLEAR POWER ELECTRIC GENERATING
PLANTS IN THE UNITED STATES, 1985***

United States**NORTHEAST****Baltimore Gas & Electric Co.**

● Calvert Cliffs 1 (Lusby, Md)	850	PWR	C-E	GE	Bechtel	Bechtel	100	1/73	5/75
● Calvert Cliffs 2 (Lusby Md)	850	PWR	C-E	W	Bechtel	Bechtel	100	1/74	4/77

Boston Edison Co.

● Pilgrim 1 (Plymouth Mass)	670	BWR	GE	GE	Bechtel	Bechtel	100	10/71	12/72
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Connecticut Yankee Atomic Power Co.

● Haddam Neck (Haddam Neck Conn)	582	PWR	W	W	S&W	S&W	100	11/67	1/68
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Consolidated Edison Co.

● Indian Point 2 (Indian Point, N Y)	873	PWR	W	W	UE&C	Wedco	100	6/69	7/74
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Duquesne Light Co.

● Beaver Valley 1 (Shippingport, Pa)	833	PWR	W	W	S&W	S&W/DLC	100	6/73	4/77
Beaver Valley 2 (Shippingport, Pa)	833	PWR	W	W	S&W	DLC	86 9	10/78	8/87

GPU Nuclear Corporation

● Oyster Creek 1 (Forked River, N J)	620	BWR	GE	GE	B&R/GE	B&R	100	2/68	12/69
● Three Mile Island 1* (Londonderry Twp , Pa)	792	PWR	B&W	GE	Gilbert	UE&C	100	9/71	9/74
● Three Mile Island 2* (Londonderry Twp , Pa)	880	PWR	B&W	W	B&R	UE&C	100	5/73	12/78

Long Island Lighting Co.

Shoreham (Brookhaven, N Y)	809	BWR	GE	GE	S&W	Utility	100	/75	10/85
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Maine Yankee Atomic Power Co.

● Maine Yankee (Wiscasset, Me)	825	PWR	C-E	W	S&W	S&W	100		12/72
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New Hampshire Yankee, Inc.

Seabrook 1 (Seabrook, N H)	1150	PWR	W	GE	UE&C	UE&C	85	11/79	8/86
Seabrook 2 (Seabrook, N H)	1150	PWR	W	GE	UE&C	UE&C	23	8/81	indef

New York Power Authority

● Indian Point 3 (Indian Point, N Y)	965	PWR	W	W	UE&C	Wedco	100	7/71	8/76
● James A. FitzPatrick (Scriba, N Y)	821	BWR	GE	GE	S&W	S&W	100	1/73	7/75

Niagara Mohawk Power Corp.

● Nine Mile Point 1 (Scriba, N Y)	610	BWR	GE	GE	Utility	S&W	100	11/68	12/69
Nine Mile Point 2 (Scriba N Y)	1085	BWR	GE	GE	S&W	S&W	92	7/78	10/86

Northeast Utilities

● Millstone 1 (Waterford, Conn)	660	BWR	GE	GE	Ebasco	Ebasco	100	6/69	12/70
● Millstone 2 (Waterford, Conn)	870	PWR	C-E	GE	Bechtel	Bechtel	100	4/74	12/75
● Millstone 3 (Waterford, Conn)	1150	PWR	W	GE	S&W	S&W	96	3/78	5/86

Pennsylvania Power & Light Co.

● Susquehanna 1 (Berwick, Pa)	1050	BWR	GE	GE	Bechtel	Bechtel	100	5/79	6/83
● Susquehanna 2 (Berwick, Pa)	1050	BWR	GE	GE	Bechtel	Bechtel	100	5/81	2/85

CONTINUED

NOTE: Readers may be interested to know that Mississippi Power & Light Company's Grand Gulf 1 boiling water reactor went into commercial operation just one minute past midnight on July 1, and so there is no "bullet" next to its name to indicate that commercial operation has begun. The deadline observed in the World List is

June 30. *Nuclear News* admits this is a near miss, but we are fussy, and moreover think that, in the long run, this will help avoid confusion.

*Retained on this list are GPU's Three Mile Island 1 and 2 units, even though these have long since been out of commercial service.

*Extracted from *Nuclear News*, August 1985/Vol. 28/No. 10. This list is updated semiannually (February and August). Reprinted with permission of *Nuclear News*.

World List of Nuclear Power Plants, cont'd

U S —Northeast, cont d

Philadelphia Electric Co.

- Peach Bottom 2 (Peach Bottom, Pa)
- Peach Bottom 3 (Peach Bottom, Pa)
- Limerick 1 (Pottstown, Pa)
- Limerick 2 (Pottstown, Pa)

Public Service Electric & Gas Co.

- Salem 1 (Salem, N J)
- Salem 2 (Salem, N J)
- Hope Creek 1 (Salem, N J)

Rochester Gas & Electric Corp.

- Robert E. Ginna (Ontario, N Y)

Vermont Yankee Nuclear Power Corp.

- Vermont Yankee (Vernon, Vt)

Yankee Atomic Electric Co.

- Yankee (Rowe, Mass)

Net MWe	Type	Reactor Supplier	Generator Supplier	Architect Engineer	Constructor	Construction stage (%)	Commercial orig. sched-ule†	Operation actual or ex-pected
1065	BWR	GE	GE	Bechtel	Bechtel	100	/71	7/74
1065	BWR	GE	GE	Bechtel	Bechtel	100	/73	12/74
1055	BWR	GE	GE	Bechtel	Bechtel	100	8/78	12/85
1055	BWR	GE	GE	Bechtel	Bechtel	31	1/80	10/90
1079	PWR	W	W	Utility	UE&C	100	/71	6/77
1106	PWR	W	W	Utility	UE&C	100	/73	10/81
1070	BWR	GE	GE	Bechtel	Bechtel	98.8	3/75	9/86
490	PWR	W	W	Gilbert	Bechtel	100	11/69	3/70
514	BWR	GE	GE	Ebasco	Ebasco	100	10/70	11/72
175	PWR	W	W	S&W	S&W	100	1/61	6/61

MIDWEST

The Cleveland Electric Illuminating Co.

- Perry 1 (North Perry, Ohio)
- Perry 2 (North Perry, Ohio)

Commonwealth Edison Company

- Dresden 2 (Morris, Ill)
- Dresden 3 (Morris, Ill)
- LaSalle County 1 (Seneca, Ill)
- LaSalle County 2 (Seneca, Ill)
- Zion 1 (Zion, Ill)
- Zion 2 (Zion, Ill)
- Byron 1 (Byron, Ill)
- Byron 2 (Byron, Ill)
- Braidwood 1 (Braidwood, Ill)
- Braidwood 2 (Braidwood, Ill)

Commonwealth Edison Company, Interstate Power Company, and Iowa-Illinois Gas and Electric Company

- Carroll County 1 (Savanna, Ill)
- Carroll County 2 (Savanna, Ill)

1205	BWR	GE	GE	Gilbert	Utility	99	7/79	12/85
1205	BWR	GE	GE	Gilbert	Utility	57	7/80	indef
794	BWR	GE	GE	S&L	UE&C	100	2/69	8/70
794	BWR	GE	GE	S&L	UE&C	100	2/70	10/71
1078	BWR	GE	GE	S&L	Utility	100	2/76	10/82
1078	BWR	GE	GE	S&L	Utility	100	2/77	6/84
1040	PWR	W	W	S&L	Utility	100	4/72	12/73
1040	PWR	W	W	S&L	Utility	100	5/73	9/74
1120	PWR	W	W	S&L	Utility	100	5/79	4/85
1120	PWR	W	W	S&L	Utility	72	3/80	10/86
1120	PWR	W	W	S&L	Utility	84	10/79	10/86
1120	PWR	W	W	S&L	Utility	56	10/80	12/87
1120	PWR	W	W	S&L		0	10/87	/2001
1120	PWR	W	W	S&L		0	10/88	/2002

NORTHEAST: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

SOUTH: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia

MIDWEST: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin

SOUTHWEST: Arizona, New Mexico, Oklahoma, Texas

WEST AND NORTHWEST: California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming

	Net MWe	Type	Reactor Supplier	Generator Supplier	Architect Engineer	Constructor	Con- struc- tion stage (%)	Commercial orig. sched- ule†	actual or ex- pected
U S —MIDWEST, cont'd									
Commonwealth Edison Co. and									
Iowa-Illinois Gas & Electric Co.									
• Quad-Cities 1 (Cordova, Ill)	789	BWR	GE	GE	S&L	UE&C	100	3/70	8/72
• Quad-Cities 2 (Cordova, Ill)	789	BWR	GE	GE	S&L	UE&C	100	3/71	10/72
Consumers Power Co.									
• Big Rock Point (Charlevoix, Mich)	63	BWR	GE	GE	Bechtel	Bechtel	100	12/62	12/62
• Palisades (South Haven, Mich)	757	PWR	C-E	W	Bechtel	Bechtel	100	7/70	12/71
Dairyland Power Cooperative									
• La Crosse BWR (Genoa, Wis)	50	BWR	Allis	Allis	S&L	Maxon	100	10/66	11/69
Detroit Edison Co.									
Fermi 2 (Newport, Mich)	1100	BWR	GE	GEC	Utility	Daniel	100	2/74	10/85
Illinois Power Co.									
Clinton 1 (Clinton, Ill)	933	BWR	GE	GE	S&L	Baldwin	94 2	6/80	7/86
Indiana & Michigan Electric Co.									
• Donald C Cook 1 (Bridgman, Mich)	1020	PWR	W	GE	AEPSC	AEPSC	100	4/72	8/75
• Donald C Cook 2 (Bridgman, Mich)	1060	PWR	W	BBC	AEPSC	AEPSC	100	4/73	7/78
Iowa Electric Light & Power Co.									
• Duane Arnold (Palo, Iowa)	538	BWR	GE	GE	Bechtel	Bechtel	100	12/73	2/75
Kansas Gas & Electric Co.,									
Kansas City Power & Light Co. and									
Kansas Electric Power									
Cooperative, Inc.									
Wolf Creek (Burlington, Kans)	1150	PWR	W	GE	Bech/S&L	Daniel	100	4/81	9/85
Nebraska Public Power District									
• Cooper (Brownville, Neb)	778	BWR	GE	W	B&R	B&R	100	4/71	7/74
Northern States Power Co.									
• Monticello (Monticello, Minn)	536	BWR	GE	GE	Bechtel	Bechtel	100	5/70	7/71
• Prairie Island 1 (Red Wing, Minn)	520	PWR	W	W	FEI	Utility	100	5/72	12/73
• Prairie Island 2 (Red Wing, Minn)	520	PWR	W	W	FEI	Utility	100	5/74	12/74
Omaha Public Power District									
• Fort Calhoun 1 (Fort Calhoun, Neb)	486	PWR	C-E	GE	G&H	G&H	100	6/71	9/73
Toledo Edison Co.									
• Davis-Besse 1 (Oak Harbor, Ohio)	906	PWR	B&W	GE	Bechtel	Bechtel	100	12/74	11/77
Union Electric Co.									
• Callaway 1 (Fulton, Mo)	1150	PWR	W	GE	Bechtel	Daniel	100	10/81	4/85
Wisconsin Electric Power Co.									
• Point Beach 1 (Two Creeks, Wis)	485	PWR	W	W	Bechtel	Bechtel	100	4/70	12/70
• Point Beach 2 (Two Creeks, Wis)	485	PWR	W	W	Bechtel	Bechtel	100	4/71	10/72
Wisconsin Public Service Corporation									
• Kewaunee (Carlton, Wis)	535	PWR	W	W	FEI	FEI	100	6/72	6/74

SOUTH

Alabama Power Company									
• Joseph M Farley 1 (Dothan, Ala)	829	PWR	W	W	SCSI/Bechtel	Daniel	100	4/75	12/77
• Joseph M Farley 2 (Dothan, Ala)	829	PWR	W	W	SCSI/Bechtel	Daniel	100	4/76	7/81
Arkansas Power & Light Co.									
• Nuclear One 1 (Russellville, Ark)	836	PWR	B&W	W	Bechtel	Bechtel	100	7/72	12/74
• Nuclear One 2 (Russellville, Ark)	858	PWR	C-E	GE	Bechtel	Bechtel	100	12/75	3/80
Carolina Power & Light Co.									
• Robinson 2 (Hartsville S C)	665	PWR	W	W	Ebasco	Ebasco	100	5/70	3/71
• Brunswick 1 (Southport, N C)	790	BWR	GE	GE	UE&C	Brown	100	3/75	3/77
• Brunswick 2 (Southport, N C)	790	BWR	GE	GE	UE&C	Brown	100	3/74	11/75
• Shearon Harris (New Hill, N C)	900	PWR	W	W	Ebasco	Daniel	91	3/77	9/86
Duke Power Co.									
• Oconee 1 (Seneca, S C)	860	PWR	B&W	GE	Utility/Bech	Utility	100	5/71	7/73
• Oconee 2 (Seneca, S C)	860	PWR	B&W	GE	Utility/Bech	Utility	100	5/72	9/74
• Oconee 3 (Seneca, S C)	860	PWR	B&W	GE	Utility/Bech	Utility	100	6/73	12/74
• McGuire 1 (Cornelius, N C)	1180	PWR	W	W	Utility	Utility	100	3/76	12/81
• McGuire 2 (Cornelius, N C)	1180	PWR	W	W	Utility	Utility	100	3/77	3/84
• Catawba 1 (Clover S C)	1145	PWR	W	GE	Utility	Utility	100	3/79	6/85
• Catawba 2 (Clover, S C)	1145	PWR	W	GE	Utility	Utility	95 6	3/80	6/87
Florida Power & Light Co.									
• Turkey Point 3 (Florida City Fla)	666	PWR	W	W	Bechtel	Bechtel	100	8/70	12/72
• Turkey Point 4 (Florida City Fla)	666	PWR	W	W	Bechtel	Bechtel	100	8/71	9/73

CONTINUED

• Units in commercial operation

† Estimated date of startup announced at time reactor was ordered

World List of Nuclear Power Plants, cont'd

	Net MWe	Type	Reactor Supplier	Generator Supplier	Architect Engineer	Constructor	Con- struc- tion stage (%)	Commercial Operation orig. sched- ule†	actual or ex- pected
U S —SOUTH, cont'd									
Florida Power & Light Co., cont'd									
• St Lucie 1 (Hutchinson Island, Fla)	827	PWR	C-E	W	Ebasco	Ebasco	100	1/73	12/76
• St Lucie 2 (Hutchinson Island, Fla)	837	PWR	C-E	W	Ebasco	Ebasco	100	9/79	8/83
Florida Power Corporation									
• Crystal River 3 (Red Level, Fla)	825	PWR	B&W	W	Gilbert	Jones	100	9/72	3/77
Georgia Power Co.									
• Edwin I Hatch 1 (Baxley, Ga)	810	BWR	GE	GE	SS/Bechtel	Utility	100	4/73	12/75
• Edwin I Hatch 2 (Baxley, Ga)	820	BWR	GE	GE	Bechtel	Utility	100	4/76	8/79
• Vogtle 1 (Waynesboro, Ga)	1100	PWR	W	GE	SS/Bechtel	Utility	79	2/78	2/87
• Vogtle 2 (Waynesboro, Ga)	1100	PWR	W	GE	SS/Bechtel	Utility	50	2/79	9/88
Gulf States Utilities Co.									
• River Bend 1 (St. Francisville, La)	940	BWR	GE	GE	S&W	S&W	98	10/79	12/85
Louisiana Power & Light Co.									
• Waterford 3 (Taft, La)	1104	PWR	C-E	W	Ebasco	Ebasco	100	1/77	7/85
Mississippi Power & Light Co.									
• Grand Gulf 1 (Port Gibson, Miss)	1250	BWR	GE	Allis	Bechtel	Bechtel	100	9/79	7/85
• Grand Gulf 2 (Port Gibson, Miss)	1250	BWR	GE	Allis	Bechtel	Bechtel	33	9/81	indef
South Carolina Electric & Gas Co.									
• Virgil C. Summer 1 (Parr, S C)	900	PWR	W	GE	Gilbert	Daniel	100	10/77	1/84
Tennessee Valley Authority									
• Browns Ferry 1 (Decatur, Ala)	1067	BWR	GE	GE	Utility	Utility	100	10/70	8/74
• Browns Ferry 2 (Decatur, Ala)	1067	BWR	GE	GE	Utility	Utility	100	10/71	3/75
• Browns Ferry 3 (Decatur, Ala)	1067	BWR	GE	GE	Utility	Utility	100	10/72	3/77
• Sequoyah 1 (Daisy, Tenn)	1148	PWR	W	W	Utility	Utility	100	10/73	7/81
• Sequoyah 2 (Daisy, Tenn)	1148	PWR	W	W	Utility	Utility	100	4/74	6/82
• Watts Bar 1 (Spring City, Tenn)	1177	PWR	W	W	Utility	Utility	99	10/76	10/85
• Watts Bar 2 (Spring City, Tenn)	1177	PWR	W	W	Utility	Utility	68	4/77	4/88
• Bellefonte 1 (Scottsboro, Ala)	1213	PWR	B&W	BBC	Utility	Utility	81	7/77	/95
• Bellefonte 2 (Scottsboro, Ala)	1213	PWR	B&W	BBC	Utility	Utility	54	4/78	/96
Virginia Power Co.									
• Surry 1 (Gravel Neck, Va)	781	PWR	W	W	S&W	S&W	100	3/71	12/72
• Surry 2 (Gravel Neck, Va)	775	PWR	W	W	S&W	S&W	100	3/72	5/73
• North Anna 1 (Mineral, Va)	893	PWR	W	W	S&W	S&W	100	3/74	6/78
• North Anna 2 (Mineral, Va)	893	PWR	W	W	S&W	S&W	100	7/75	12/80
SOUTHWEST									
Arizona Public Service Co.									
• Palo Verde 1 (Wintersburg, Ariz)	1270	PWR	C-E	GE	Bechtel	Bechtel	100	5/81	late 85
• Palo Verde 2 (Wintersburg, Ariz)	1270	PWR	C-E	GE	Bechtel	Bechtel	99 7	11/82	mid 86
• Palo Verde 3 (Wintersburg, Ariz)	1270	PWR	C-E	GE	Bechtel	Bechtel	96 4	5/84	mid 87
Houston Lighting & Power Company									
• South Texas Project 1 (Palacios, Tex)	1250	PWR	W	W	Bechtel	Ebasco	80	10/80	6/87
• South Texas Project 2 (Palacios, Tex)	1250	PWR	W	W	Bechtel	Ebasco	54	3/82	6/89
Texas Utilities Generating Company									
• Comanche Peak 1 (Glen Rose, Tex)	1150	PWR	W	Allis	G&H	B&R	99	1/80	/86
• Comanche Peak 2 (Glen Rose, Tex)	1150	PWR	W	Allis	G&H	B&R	74	1/82	/87
WEST AND NORTHWEST									
Pacific Gas & Electric Co.									
• Diablo Canyon 1 (Avila Beach, Calif)	1084	PWR	W	W	Utility	Utility	100	5/72	5/85
• Diablo Canyon 2 (Avila Beach, Calif)	1106	PWR	W	W	Utility	Utility	100	7/74	12/85
Portland General Electric Co.									
• Trojan (Prescott, Ore)	1130	PWR	W	GE	Bechtel	Indep	100	9/74	5/76
Public Service Company of Colorado									
• Fort St. Vrain (Platteville, Colo)	330	HTGR	GA	GE	S&L	GA	100	4/72	1/79
Sacramento Municipal Utility District									
• Rancho Seco (Clay Station, Calif)	913	PWR	B&W	W	Bechtel	Bechtel	100	5/73	4/75
Southern California Edison and San Diego Gas & Electric Co.									
• San Onofre 1 (San Clemente, Calif)	436	PWR	W	W	Bechtel	Bechtel	100		1/68
• San Onofre 2 (San Clemente, Calif)	1100	PWR	C-E	GEC	Bechtel	Bechtel	100	6/75	8/83
• San Onofre 3 (San Clemente, Calif)	1100	PWR	C-E	GEC	Bechtel	Bechtel	100	6/75	4/84
United States Department of Energy*									
• Hanford-N (Richland, Wash)	860	LGR	GE	GE	B&R	B&R	100		7/66

*Power is extracted by WPPSS through the Hanford Generating Project, the reactor is owned by the DOE

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	Net MWe	Type	Reactor Supplier	Generator Supplier	Architect Engineer	Constructor	Con- struc- tion stage (%)	Commercial orig. sched- ule+ or ex- pected
U.S. —WEST & NORTHWEST, cont'd								
Washington Public Power Supply System								
• WNP-2 (Richland, Wash.)	1100	BWR	GE	W	B&R	Bechtel	100	9/77 12/84
WNP-1 (Richland, Wash.)	1250	PWR	B&W	W	UE&C	Bechtel	62 5	9/80 indef.
WNP-3 (Satsop, Wash.)	1240	PWR	C-E	W	Ebasco	Ebasco	75	3/82 indef.
U.S. Total (129 units)	118 956							

Abbreviations used in this table

A-A: ASEA-Atom (Sweden)
AC: Acres Canatom (Canada)
ACEC: Ateliers de Constructions Electriques de Charleroi S A (Belgium)
ACEC: ACEC with COP (Belgium)
ACECOWEN: ACECO with Westinghouse (Belgium)
ACLF group: ACECO/Creusot-Loire/Framatome/Westinghouse Electric Energy Systems Europe (France)
ADF: Auxeltra-Delens-Francois
AECL: Atomic Energy of Canada Ltd
AEE: Atomenergosexport (USSR) (formerly TPE Technopromexport)
AEG: Allgemeine Elektricitäts-Gesellschaft Aeg Telefunken (W. Germany)
AEI: Associated Electric Industries Ltd (U.K.)
AEPSC: American Electric Power Service Corp. (U.S.)
AETEA: Agroman EyT Ea (Spain)
AGR: advanced gas-cooled reactor
Alis: Alis-Chalmers (U.S.)
Aisthom: Ste Generale de Constructions Electriques et Mechaniques (France)
AMN: Ansaldo Meccanico Nucleare SpA (Italy)
APC: Atomic Power Construction Ltd (U.K.)
ARGE KKKU: Dyckerhoff & Widmann AG Wayss & Freitag AG Hegdtkamp (FRG)
ASGEN: Ansaldo San Giorgio Compagnia Generale (Italy)
Aux: Auxini Ingenieria Espanola SA (Spain)
Bal: Balfour Beatty & Co. (U.K.)
BAM: Bataafsche Aanneming Maatschappij NV (The Netherlands)
BBC: Brown Boveri & Cie (Switzerland)
BBR: Babcock-Brown Boveri Reaktor GmbH (W. Germany)
Becht: Bechtel Corporation (U.S.)
BHEL: Bharat Heavy Electrical (India)
BLWR: same as BWR
BNDC: British Nuclear Design & Construction Ltd (U.K.)
B&R: Burns & Roe Inc. (U.S.)
B&V: Black & Veatch (U.S.)
B&W: Babcock & Wilcox Co. (U.S.)
BRAUN: C. F. Braun & Co. (U.S.)
Brown: Brown & Root Inc. (U.S.)
BWR: boiling water reactor
C-B: Campenon-Bernard (France)
CdA: Condotte d'Acqua (Italy)
C-E: Combustion Engineering Inc. (U.S.)
CEA: Commissariat a l'Energie Atomique (France)
CEM: Compagnie Electro Mechanique (France)
CFE: Cie d'Enterprises CFE S A (Belgium)
CGE: Canadian General Electric
Chag: Chagnaud (France)
Cle GE: Cie Generale d'Electricite (France)
CITRA: Compagnie Industrielle de Travaux (France)
CL: Creusot-Loire (France)
CM: Chantiers Modernes (France)
CNO: Constructora Roberto Oldebrecht (Brazil)
COP/TOSI/ACEC: Cockenil Ougree-Providence/Franco Tosi SpA/Ateliers de Constructions Electriques de Charleroi SA (Belgium)
CTAFMC: CFe Travaux Astrolbel General Contractors Francois et Fils Maurice Delens Campenon Bernard (Belgium)
CTL: Canatom Ltd (Canada)
DAE: Department of Atomic Energy (India)
Daniel: Daniel Construction Co. (U.S.)
D-L: Delattre Levrier (France)
DOE: Department of Energy (U.S.)

EA: Empresarios Agrupados (Spain)
E&B: Emch & Berger (Switzerland)
Ebasco: Ebasco Services Inc. (U.S.)
ECC: Engineering Construction Corp. (India)
EEC: English Electric Co. Ltd. (Canada)
EEW: English Electric and G. Wimpey Group (U.K.)
EI: Elettronucleare Italiana (Italy)
Elin: Elin Union AG (W. Germany)
ENB: Empresa Nacional Bazan (Spain)
ENSA: Equipos Nucleares SA (Spain)
EPDC: Electric Power Development Co. Ltd. (Japan)
ERBE: Hungarian Company for Power Plant Investment
ETOCEA: Entrecanales y Oisa (Spain)
EW: ElectroWatt Ltd. (Switzerland)
EyT: Entrecanales y Tavora SA (Spain)
FEI: Fluor Engineers Inc. (U.S.)
Fou: Fougerolle (France)
Fra: Framatome Societe Franco Americaine de Constructions Atomiques SA (France)
FRAMACECO: Framatome with ACECO (Belgium)
Fuji: Fuji Electric Co. Ltd. (Japan)
GA: General Atomic Company (U.S.)
GAAA: Groupement pour les Activites Atomiques et Avancees (France)
GC: Groupement Constructeurs Francais (France)
GCHWR: gas cooled heavy water-moderated reactor
GCR: gas-cooled reactor
GE: General Electric Co. (U.S.)
GENC: General Electric Co. Turbine Generated Ltd. (U.K.)
GETSCO: General Electric Technical Services Co.
G&H: Gibbs & Hill Inc. (U.S.)
G&HE: Gibbs & Hill Espanola SA (Spain)
Gilbert: Gilbert Associates Inc. (U.S.)
Gil/Com: Gilbert/Commonwealth (U.S.)
GKW: Gemeinschaftskraftwerk Weser GmbH (FRG)
GTM: Grands Travaux de Marseille (France)
Haz: Hazama Gumi Co. (Japan)
HCC: Hindustan Construction Co. (India)
Hoch: Hochtief AG (W. Germany)
H-P: Howden-Parsons (Canada)
HQ: Hydro-Quebec (Canada)
HRB: Hochttemperatur-Reaktorbau GmbH (W. Germany)
HTGR: high-temperature gas-cooled reactor
HWLWR: heavy-water-moderated boiling light water-cooled reactor
Iber: Iberduero SA (Spain)
Imp: Imprest
INB: Internationale Natrium Brutreaktorbau GmbH (W. Germany)
INITEC: Empresa Nacional de Ingenieria y Tecnologia SA (Spain)
Int: Interatom (W. Germany)
IyP: Informas y Projectas SA (Spain)
JL: John Laing Construction Ltd. (U.K.)
Jones: J. A. Jones Construction Co. (U.S.)
J-S: Jeumont-Schneider (France)
Kaiser: Kaiser Engineers (U.S.)
KTHTR: Konsortium THTR—Brown Boveri & Cie AG Hochttemperatur-Reaktorbau GmbH Nukem GmbH (W. Germany)
Kum: Kumagaya Gumi Co. (Japan)
KWU: Kraftwerk Union AG (W. Germany)
L&T: Larsen & Toubro (India)
LGR: light water cooled graphite-moderated reactor
LMFBR: liquid metal fast breeder reactor
LWBR: light water breeder reactor
LWCHW: light water cooled heavy-water moderated reactor
MAPI: Mitsubishi Atomic Power Industries Inc. (Japan)
Maxon: Maxon Construction Company (U.S.)
McAlp: Sir Robert McAlpine & Sons Ltd. (U.K.)

MCING: Motor-Columbus Consulting Engineers Inc. (Switzerland)
MECO: Montreal Engineering Co. (Canada)
MEL: Mitsubishi Electric Corporation (Japan)
MHI: Mitsubishi Heavy Industries Ltd. (Japan)
MNI: Ministry of Nuclear Industry (PRC)
NCC: Nuclear Civil Constructors (U.K.)
NEI: Northern Engineering Industries (U.K.)
Nersa: Nersa NV (The Netherlands)
Nersa: Centrale Nucleaire Europeenne A Neutrons Rapides (France)
NIRA: Nucleare Italiana Reattori Avanzati (Italy)
NNC: National Nuclear Corporation (U.K.)
NPC: Nuclear Power Co. Ltd. (U.K.)
Nuclebras: Empresas Nucleares Brasileiras SA
Nuculen: Nuclebras Engenaria SA (Brazil)
Nucleop: Nuclebras Equipamentos Pesados SA
NWK: Nordwestdeutsche Kraftwerke AG (FRG)
OBAY: Obayashi Gumi Co. (Japan)
OH: Ontario Hydro (Canada)
OPS: Offshore Power Systems (U.S.)
Par (U.K.): C. A. Parsons and Co. Ltd. (U.K.)
Parsons: Ralph M. Parsons Co. (U.S.)
PE: Promon Engenharia SA (Brazil)
PH: Philip Holzman (W. Germany)
PHWR: pressurized heavy water-moderated and -cooled reactor
PWR: pressurized water reactor
Rateau: Rateau Ste. (France)
R & C: Richardson & Cruddas (I) (India)
RDM: Rotterdamse Droogdok Maatschappij (The Netherlands)
RPL: Reyrolle Parsons Ltd. (U.K.)
RW: Richardsons Westgarth Ltd. (U.K.)
SACM: Societe Alsacienne de Constructions Mechaniques (France)
SB: Spie Batignolles SA (France)
SCG: Skanska Cementgjuteriet
SCSI: Southern Company Services Inc.
SeB: Sainrapt et Brice (France)
SEN: Sener SA (Spain)
SGE: Societe Generale d'Enterprises (France)
SHI: Sumitomo Heavy Industries Ltd. (Japan)
SK: Sydvenska Kraft AB (Sweden)
S&L: Sargent & Lundy Engineers (U.S.)
S-L: Stal-Laval Turbin AB (Sweden)
SNC: Surveyer Nenniger & Chenevert Inc. (Canada)
SO: Siemens Österreich (Austria)
SOCIA: Societe pour l'Industrie Atomique (France)
SOGENE: Societa Generale per Lavoro e Pubbliche Utilita (Italy)
SR: Stearns Roger Corp. (U.S.)
SS: Southern Services Inc. (U.S.)
SSPB: Swedish State Power Board
Stork: Koninklijke Machinefabriek Stork (The Netherlands)
S&W: Stone & Webster Engineering Corp. (U.S.)
T&B: Townsend & Bottom Inc.
TE: Tracton Electricite
THTR: thorium high-temperature reactor
TNPG: The Nuclear Power Group (U.K.)
TPC: Taiwan Power Company
TR: Tecnicas Reunidas SA (Spain)
TW: Taylor Woodrow Construction Ltd. (U.K.)
UE&C: United Engineers & Constructors (U.S.)
VANEA: Vandellos-Empresarios Agrupados (Spain)
VBB: AB Vattenbyggnadsbyran
VME: Verenigde Machinefabrieken NV (The Netherlands)
W: Westinghouse Electric Corporation (U.S.)
Wedco: a subsidiary of Westinghouse Electric Corporation (U.S.)
WIL: Walchandnagar Industries Ltd. (India)
Zachry: H. B. Zachry Company (U.S.)

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APPENDIX C:

**FOUR-DIGIT CODE OF ACCOUNTS — PHASE VI
UPDATE OF THE ENERGY ECONOMIC DATA BASE**

TABLE C.1 Costs for Unit 1, 1190 MW_e BWR (7-17-84) Power Plant at Middletown; BWR Model, EEDB Phase VI, 01/83 Regulatory Basis; Cost Basis: Year of Steam Supply System Purchase

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
21	Structures + Improvements				
211	Yardwork				
211.1	General Yardwork		359	4260	2878
211.4	Railroads		0	1494	1380
211.7	Structure Associated Yardwork		0	13962	6374
	Subtotal		359	19716	10632
212	Reactor Containment Bldg.	2.7 x 10 ⁶			
212.1	Building Structure		315	74826	36839
212.2	Building Services		1598	2792	763
	Subtotal		1913	77617	37602
213	Turbine Room + Heater Bay	12.3 x 10 ⁶			
213.1	Building Structure		0	39505	22173
213.2	Building Services		1860	3935	1121
	Subtotal		1860	43440	23295
214	Security Building	5.7 x 10 ⁴			
214.1	Building Structure		0	761	384
214.2	Building Services		75	399	103
	Subtotal		75	1160	487
215	Auxiliary Bldg. + Tunnels	1 x 10 ⁶			
215.1	Building Structure		0	20965	7910
215.2	Building Services		431	3326	806
	Subtotal		431	24291	8716
216	Waste Process Building	7 x 10 ⁵			
216.1	Building Structure		0	10781	4469
216.2	Building Services		510	1553	381
	Subtotal		510	12333	4850

TABLE C.1 (Cont'd)

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
217	Fuel Storage Building	1.6 x 10 ⁶			
217.1	Building Structure		0	8585	4704
217.2	Building Services		1010	927	306
	Subtotal		1010	9512	5010
218	Other Structures				
218A	Control Room/Diesel Generator Bldg.	1.2 x 10 ⁶ / 6.6 x 10 ⁵			
218A.1	Building Structure				
218A.2	Building Services		1757	7141	1162
	Subtotal		1757	23895	8338
218B	Administration + Service Bldg.	1.5 x 10 ⁶			
218B.1	Building Structure				
218B.2	Building Services		874	2264	536
	Subtotal		874	5715	2717
218D	Fire Pump House, incl. Foundations	3.4 x 10 ⁴			
218D.1	Building Structure				
218D.2	Building Services		37	95	19
	Subtotal		37	338	147
218K	Pipe Tunnels				
218K.1	Building Structure				
218K.2	Building Services		0	40	58
	Subtotal		0	996	358
218L	Technical Support Center	6.8 x 10 ⁵			
218L.1	Building Structure				
218L.2	Building Services		60	35	9
	Subtotal		60	421	203
218S	Holding Pond				
218S.1	Pond Structure		0	201	64
	Subtotal		0	201	64

TABLE C.1 (Cont'd)

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
218T	Ultimate Heat Sink Structure	1.5 x 10 ⁶			
218T.1					
218T.2	Building Services		41	179	48
	Subtotal		41	6720	2170
218V	Contractor Room Emergency Air Intake Structure				
218V.1	Building Structure		0	215	75
	Subtotal		0	215	75
218Z	Waste Water Treatment Bldg.	4 x 10 ⁴	0	374	210
	Subtotal		2769	38876	14281
22	Reactor Plant Equipment				
220	Nuclear Steam Supply System				
220A	Nuclear Steam Supply (NSSS)				
220A.1	Quoted NSSS Price		131242	0	0
	Subtotal		131242	0	0
220B	NSSS Options		131242	0	0
	Subtotal		131242	0	0
221	Reactor Equipment				
221.1	Reactor Vessel + Accessory		815	5053	3301
221.2	Reactor Control Devices		843	22818	4724
	Subtotal		843	22818	4724
222	Main Heat Transfer Export System				
222.1	Reactor Water Recirculator System		619	4318	370
	Subtotal		619	4318	370

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
223	Safeguards System			
223.1	Residual Heat Removal System	4329	6844	585
223.2	Reactor Core Isolation Cooling System	545	657	52
223.3	High Pressure Core Spray System	1547	2644	227
223.4	Low Pressure Core Spray System	626	1128	97
223.5	Combustible Gas Control System	1441	567	48
223.6	Standby Liquid Control System	67	87	9
223.7	Standby Gas Treatment System	711	409	35
	Subtotal	9266	12335	1052
224	Rad Waste Processing			
224.1	Liquid Waste System	7993	7895	1799
224.2	Gas Waste Processing	2334	1195	103
224.3	Solid Waste System	2841	1254	120
	Subtotal	13876	10744	2057
225	Fuel Handling + Storage			
225.1	Fuel Handling Tools + Equipment	825	423	35
225.2	Remote Viewing Equipment	1	59	4
225.3	Service Platforms	5	75	7
225.4	Fuel Storage, Cleaning + Inspection Equipment	1236	1247	118
	Subtotal	2067	1804	164
226	Other Reactor Equipment			
226.4	Reactor Water Cleanup System	737	518	42
226.6	Leak Detection Systems	464	249	14
226.7	Auxiliary Cool System	8139	20097	3093
226.8	Maintenance Equipment	0	74	453
226.9	Miscellaneous Systems	338	347	25
	Subtotal	9679	21285	3627

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
227	Instrumentation + Control			
227.1	Benchboard, Panels + Racks	2911	1632	69
227.2	Process Computer	2675	377	33
227.3	Monitoring Systems	2969	1143	50
227.4	Plant Control Systems	1682	607	26
227.5	Reactor Plant I+C Tubing and Fittings	229	4578	395
227.9	TMI Instrumentation	2167	1326	25
	Subtotal	12633	9663	598
228	Reactor Plant Misc. Items			
228.1	Field Painting	0	573	155
228.2	Qualification of Welders	0	3693	350
228.3	Reactor Plant Insulation	0	0	0
	Subtotal	0	1450	2375
23	Turbine Plant Equipment			
231	Turbine Generator			
231.1	Turbine Generator + Accessory	109048	4983	435
231.2	Foundations	407	2951	985
231.4	Lubricating Oil System	275	369	66
231.5	Gas Systems	303	418	36
231.6	Master Separator/Reheater Drain System	2280	2433	209
	Subtotal	112312	11153	1730
233	Condensing Systems			
233.1	Condenser Equipment	10994	2522	217
233.2	Condensate System	7320	12034	1820
233.3	Gas Removal System	704	739	62
233.4	Turbine Bypass System	183	0	0
233.5	Condensate Polishing	2380	198	15
	Subtotal	21581	15495	2114
234	Feed Heating System			
234.1	Feedwater Heaters (FWH)	3366	464	40
234.2	Feedwater System	8785	9144	787
234.3	Extraction Steam System	1432	1724	148
234.4	FWH Vent + Drain System	1760	2079	178
	Subtotal	15343	13411	1152

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
235	Other Turbine Plant Equipment			
235.1	Main Vapor Piping System	10441	15030	1275
235.2	Turbine Auxiliaries	8	68	4
235.3	TB Closed Cleaning Water System	3395	4070	349
235.4	Demineralized Water Make-up System	2166	3143	601
235.5	Chemical Treatment System	57	24	2
235.6	Neutralization System	104	38	4
	Subtotal	16172	22374	2235
236	Instrumentation + Control			
236.1	Process I+C Equipment	1481	1308	47
236.2	Process Computer			
236.3	Turbine Plant I+C Tubing	221	4590	395
	Subtotal	1702	5898	442
237	Turbine Plant Miscellaneous Items			
237.1	Field Painting	0	3440	472
237.3	Turbine Plant Insulation	0	2341	3034
	Subtotal	0	5782	3505
24	Electric Plant Equipment			
241	Switchgear			
241.1	General Equipment Switchgear	1289	68	33
241.2	Station Service Switchgear	8541	576	50
	Subtotal	9830	645	83
242	Station Service Equipment			
242.1	Station Service and Startup Transfer	1725	379	89
242.2	Unit Substations	3502	582	51
242.3	Auxiliary Power Sources	12581	2714	285
	Subtotal	17808	3675	425

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
243	Switchboards			
243.1	Control Panels	1198	268	32
243.2	Auxiliary Power and Signal Boards	190	108	92
	Subtotal	1388	376	124
244	Protective Equipment			
244.1	General Station Ground System	0	2401	634
244.2	Fire Detection + Suppression	0	0	0
244.3	Lightning Protection	0	71	68
244.4	Cathodic Protection	0	343	323
244.5	Heat Tracing + Freeze Protection	0	231	623
	Subtotal	0	3046	1647
245	Electric Structure + Wiring Container			
245.1	Underground Duct Runs	0	4896	1259
245.2	Cable Tray	0	8001	1910
245.3	Conduit	0	20567	1863
	Subtotal	0	33465	5033
246	Power and Control Wiring			
246.1	Generator Circuits Wiring	987	782	67
246.2	Station Service Power Wiring	0	2227	1955
246.3	Control Cable	0	9291	4581
	Subtotal	1611	20390	10085
25	Miscellaneous Plant Equipment			
251	Transportation and Lift Equipment			
251.1	Cranes and Hoists	2253	1399	520
	Subtotal	2253	1399	520

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
252	Air, Water + Steam Service System			
252.1	Air Systems	1550	8534	506
252.2	Water Systems			
252.21	Service Water System	2207	4117	354
	Subtotal	4930	15780	3804
252.3	Auxiliary Steam System	2242	4238	318
252.4	Plant Fuel Oil System	0	180	91
	Subtotal	8721	28732	4719
253	Communications Equipment			
253.1	Local Communications System	0	720	265
253.2	Signal Systems	1956	3716	320
	Subtotal	1956	4435	585
254	Furnishings + Fixtures			
254.1	Safety Equipment	0	7	14
254.2	Chemical Lab Shop	1003	206	13
254.3	Office Equip. + Furnishings	120	3	0
254.4	Change Room Equipment	140	30	3
254.5	Environment Monitoring Equipment	648	352	31
254.6	Dining Facilities	176	27	2
	Subtotal	2088	625	63
255	Waste Water Treatment Equipment	1615	1811	0
26	Main Cond. Heat Reject System			
261	Structures			
261.1	Make-up Water Int. + Discharge Storage	8	563	292
261.2	Circ. Water Pump House	94	1494	441
261.3	Make-up Water Pretreatment Bldg.		63	821
562				
261.4	Cooling Tower Sewerage Bldg.	94	192	73
	Subtotal	260	3070	1368

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
262	Mechanical Equipment			
262.1	Heat Rejection System	22230	19083	2322
	Subtotal	22230	19083	2322
91	Construction Services			
911	Temporary Construction Factory			
911.1	Temporary Buildings	0	50206	5297
911.2	Temporary Facilities	0	106313	23588
	Subtotal	0	156519	28886
912	Construction Tools & Equipment			
912.1	Major Equipment	0	7959	37582
912.2	Miscellaneous Vehicles			
912.3	Purchase of Small Tools	0	937	10595
912.4	Expendable Supplies	0	0	15592
912.5	Safety Equipment & Inspection	0	821	1000
	Subtotal	0	9717	64768
913	Payroll Insurance and Taxes (.17L including on-site labor)			
913.1	Social Security Tax			
913.2	State + Fed. Unemployment			
913.3	Workmens Compensation Insurance			
913.4	P.L. + P.D. Insurance	0	0	0
	Subtotal	0	0	0
93	Field Office Engrg. & Service			
931	Field Office Expenses			
931.1	Office Furniture & Equipment	0	441	5797
931.2	Telephone and Communications	0	232	2299
931.3	Office Supplies	0	0	7496
931.4	First Aid & Medical Expense	0	696	100
	Subtotal	0	1369	15692
932	Field Job Supervision			
932.1	Salaries			
932.11	Salaries (1/2)	88977	0	0
932.12	Salaries (1/2)	88977	0	0
	Subtotal	177953	0	0

TABLE C.1 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
932.2	Salaries	0	0	0
932.3	Direct Payroll Expenses	52174	0	0
932.4	Overhead Loading	33848	0	0
932.5	Relocation Expense-Allowance	17525	0	0
932.6	Fee for Construction Services			
932.61	Home Office	1051	0	0
	Subtotal	25987	0	0
932.7	Survey Engineers (Manual)	0	12534	0
	Subtotal	0	12534	0
933	Field QA/QC			
933.1	Salaries	11516	0	0
933.2	Direct Payroll Expenses	3455	0	0
933.3	Overhead Loading	2203	0	0
933.4	Expenses	2904	0	0
933.5	Construction Training Meeting (Crft.)	0	7195	0
	Subtotal	20079	7195	0
934	Plant Startup and Text			
934.1	Salaries	7210	0	0
934.2	Direct Payroll Expenses	2163	0	0
934.3	Overhead Loading	5147	0	0
934.4	Expenses - % of Salaries	1001	0	0
	Subtotal	15522	0	0
94	Owner's Costs			
941	Engineering and WA	29558	0	0
942	Taxes and Insurance	69013	0	0
943	Spare Parts	29558	0	0
944	Staff Training	19793	0	0
945	Owner's G&A	59116	0	0

TABLE C.2 Costs for Unit 1, 1139 MW_e PWR (7-16-84) Power Plant at Middletown; PWR Model, EEDB Phase VI, 01/83 Regulatory Status; Cost Basis: Year of Steam Supply System Purchase

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
21	Structures + Improvements				
211	Yardwork				
211.1	General Yardwork		359	4228	2797
211.4	Railroads		0	1499	1377
211.7	Structure Associated Yardwork		0	14012	6359
	Subtotal		359	19739	10533
212	Reactor Containment Bldg.	3 x 10 ⁶			
212.1	Building Structure		1821	64563	27753
212.2	Building Services		1029	2717	871
	Subtotal		2851	67280	28624
213	Turbine Room + Heater Bay	7.5 x 10 ⁶			
213.1	Building Structure		0	16662	13717
213.2	Building Services		538	2930	839
	Subtotal		538	19592	14556
214	Security Building	5 x 10 ⁴			
214.1	Building Structure		0	764	383
214.2	Building Services		75	401	103
	Subtotal		75	1165	486
215	Prim Aux. Building + Tunnels	1.1 x 10 ⁶			
215.1	Building Structure		0	13360	5044
215.2	Building Services		2962	3700	655
	Subtotal		2962	17060	5699
216	Waste Process Building	1.8 x 10 ⁶			
216.1	Building Structure		0	13538	5361
216.2	Building Services		583	1823	447
	Subtotal		583	15360	5808

TABLE C.2 (Cont'd)

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
217	Fuel Storage Building	6.3 x 10 ⁵			
217.1	Building Structure		0	5680	3374
217.2	Building Services		937	935	266
	Subtotal		937	6614	3640
218	Other Structures				
218A	Control Room/Diesel Generator Bldg.	1.7 x 10 ⁶			
218A.1	Building Structure		0	13906	6040
218A.2	Building Services		1579	6591	1055
	Subtotal		1579	20497	7095
218B	Administration + Service Bldg.	1.5 x 10 ⁶			
218B.1	Building Structure		0	3463	2176
218B.2	Building Services		873	2271	535
	Subtotal		873	5734	2711
218D	Fire Pump House, incl. Foundations	3.4 x 10 ⁴			
218D.1	Building Structure		0	244	128
218D.2	Building Services		37	95	19
	Subtotal		37	339	147
218E	Emergency Feed Pump Bldg.	6.6 x 10 ⁶			
218E.1	Building Structure		0	2381	785
218E.2	Building Services		21	332	97
	Subtotal		21	2713	882
218F	Manway Tunnels (RCA Tunnels)				
218F.1	Building Services		0	835	246
218F.2	Building Services		0	153	31
	Subtotal		0	988	277
218G	Electric Tunnels				
218G.2	Building Services		5	43	15
	Subtotal		5	43	15

TABLE C.2 (Cont'd)

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
218H	Non-Essential Sewerage Bldg.	1.2 x 10 ⁵			
218H.1	Building Structure		0	338	217
218H.2	Building Services		21	109	43
	Subtotal		21	447	260
218J	Main Steam + Feed Water Pipe Enclosure	2.8 x 10 ⁵			
218J.1	Building Structure		0	7774	2911
218J.2	Building Service		32	846	200
	Subtotal		32	8621	3111
218K	Pipe Tunnels				
218K.1	Building Structure		0	331	78
218K.2	Building Service		0	33	33
	Subtotal		0	363	111
218L	Technical Support Center	6 x 10 ⁴			
218L.1	Building Structure		0	385	193
218L.2	Building Services		60	35	9
	Subtotal		60	423	202
218M	Hydrogen Recombiner Structure				
218M.1	Building Structure		0	156	65
218M.2	Building Services		4	5	0
	Subtotal		4	161	65
218P	Contain. EQ Hatch Missile Shield				
218P.1	Shield Structure		0	218	51
	Subtotal		0	218	51
218S	Holding Pond				
218S.1	Pond Structure		0	202	64
	Subtotal		0	202	64

TABLE C.2 (Cont'd)

Account No.	Account Title	Building Volume (ft ³)	Overnight Costs (\$000 1983)		
			Factory Equipment	Site Labor	Site Materials
218T	Ultimate Heat Sink Structure	1.5 x 10 ⁶			
218T.1	Building Structure		0	6323	2023
218T.2	Building Services		41	182	48
	Subtotal		41	6505	2071
218V	Control Room Emergency Air Intake Structure				
218V.1	Building Structure		0	216	75
	Subtotal		0	216	75
218Z	Waste Water Treatment Building	4 x 10 ⁴			
			0	375	209
22	Reactor Plant Equipment				
220	Nuclear Steam Supply System				
220A	Nuclear Steam Supply (NSSS)				
220A.1	Quoted NSSS Price		139520	0	0
220B	NSSS Options		0	0	0
	Subtotal		139520	0	0
221	Reactor Equipment				
221.1	Reactor Vessel + Accessory		774	3747	3224
221.2	Reactor Control Devices		0	557	63
	Subtotal		774	4304	3287
222	Main Heat Transfer Export System				
222.1	Reactor Core Coolant System		3064	10907	1158
	Subtotal		3064	10907	1158
223	Safeguards System				
223.1	Residual Heat Removal System		1113	3290	300
223.3	Safety Injection System		1396	4011	799

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
223.4	Containment Spray System	3946	6723	580
223.5	Combustible Gas Control System	1434	570	48
	Subtotal	7889	14594	1727
224	Radwaste Processing			
224.1	Liquid Waste System	7547	9221	1086
224.2	Rad Gas Waste Processing	1263	363	24
224.3	Solid Waste System	2305	1452	138
	Subtotal	11115	11035	1248
225	Fuel Handling + Storage			
225.1	Fuel Handling Tools + Equipment	2392	411	36
225.3	Service Platforms	102	30	3
225.4	Fuel Storage Cleaning + Inspection Equipment	1792	1420	133
	Subtotal	4286	1861	172
226	Other Reactor Plant Equipment			
226.1	Inert Gas System	825	1491	128
226.3	Reactor Makeup Water System	882	2476	501
226.4	Coolant Treatment & Recycle	6945	14168	2470
226.6	Fluid Leak Detection System	147	21	1
226.7	Auxiliary Cooling System	9544	19795	3033
226.8	Maintenance Equipment	0	74	440
226.9	Sampling Equipment	339	349	26
	Subtotal	18683	38375	6598
227	RX Instrumentation + Control			
227.1	Benchboard, Panels + Racks	2304	1175	50
227.2	Process Computer	2675	379	33
227.3	Monitoring Systems	2833	1104	53
227.4	Plant Control Systems	2258	863	75
227.5	RX Plant I+C Tubing + Fitting	183	3841	329

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
227.9	TMI Instrumentation	2167	1332	25
	Subtotal	12419	8695	564
228	Reactor Plant Misc. Items			
228.1	Field Painting	0	576	153
228.2	Qualification of Welders	0	3710	349
228.3	Standard NSSS Valve Package	2341	0	0
228.4	Reactor Plant Insulation	0	1405	2587
	Subtotal	2341	5691	3088
23	Turbine Plant Equipment			
231	Turbine Generator			
231.1	Turbine Generator + Accessory	107663	5195	441
231.2	Foundations	407	2950	982
231.4	Lubricating Oil System	275	369	66
231.5	Gas Systems	300	408	35
231.6	Master Separator/Reheater Drain System	1860	1523	131
	Subtotal	110505	10445	1654
233	Condensing Systems			
233.1	Condenser Equipment	10465	2416	207
233.2	Condensate System	6802	11225	1746
233.3	Gas Removal System	737	700	59
233.4	Turbine Bypass System	234	0	0
233.5	Condensate Polishing	2380	198	15
	Subtotal	20618	14540	2027
234	Feed Heating System			
234.1	Feedwater Heaters (FWH)	3443	464	40
234.2	Feedwater System	9277	9529	818
234.3	Extraction Steam System	1393	1635	140
234.4	FWH Vent + Drain System	1738	2016	172
	Subtotal	15850	13644	1169

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
235	Other Turbine Plant Equipment			
235.1	Main Vapor Piping System	7688	15014	1271
235.2	Turbine Auxiliaries	8	68	4
235.3	TB Closed Cleaning Water System	2881	4044	346
235.4	Demineralized Water Make-up System	2317	3144	599
235.5	Chemical Treatment System	57	24	2
235.6	Neutralization System	104	38	4
	Subtotal	13055	22333	2227
236	Instrumentation + Control			
236.1	Process I+C Equipment	1558	1340	49
236.2	Process Computer	0	0	0
236.3	Turbine Plant I+C Tubing	181	3957	340
	Subtotal	1739	5298	389
237	Turbine Plant Misc. Items			
237.1	Field Painting	0	1220	261
237.2	Qualification of Welders	0	2220	209
237.3	Turbine Plant Insulation	0	2323	2852
	Subtotal	0	5763	3323
24	Electric Plant Equipment			
241	Switchgear			
241.1	General Equipment Switchgear	1289	68	34
241.2	Station Service Switchgear	8778	525	46
	Subtotal	10067	593	80
242	Station Service Equipment			
242.1	Station Service and Startup Transformer	1879	380	89
242.2	Unit Substations	3742	634	55
242.3	Auxiliary Power Sources	10217	1921	203
	Subtotal	15838	2934	347

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
243	Switchboards			
243.1	Control Panels	1198	268	32
243.2	Aux. Power & Signal Boards	190	108	92
	Subtotal	1388	376	124
244	Protective Equipment			
244.1	General Station Ground System	0	2403	632
244.2	Fire Detection + Suppression	0	0	0
244.3	Lightning Protection	0	71	68
244.4	Cathodic Protection	0	344	322
244.5	Heat Tracing + Freeze Protection	0	231	621
	Subtotal	0	3048	1643
245	Electric Structure + Wiring Container			
245.1	Underground Duct Runs	0	4738	1214
245.2	Cable Tray	0	7915	1884
245.3	Conduit	0	20216	1825
	Subtotal	0	32869	4922
246	Power and Control Wiring			
246.1	Generator Circuits Wiring	987	782	67
246.2	Station Service Power Wiring	0	2127	1807
246.3	Control Cable	0	8999	4423
246.4	Instrument Wire	0	8099	3581
246.5	Containment Penetrations	692	331	28
	Subtotal	1680	20338	9906
25	Miscellaneous Plant Equip.			
251	Transportation & Lift Equipment			
251.1	Cranes & Hoists	3014	1380	475
	Subtotal	3014	1380	475

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
252	Air, Water + Steam Service System			
252.1	Air Systems	1546	8302	492
252.2	Water Systems	4898	15575	3930
252.3	Auxillary Steam System	2244	4246	317
252.4	Plant Fuel Oil System	0	180	91
	Subtotal	8687	28302	4830
253	Communications Equipment			
253.1	Local Communications System	0	721	264
253.2	Signal Systems	1956	3720	319
	Subtotal	1956	4441	583
254	Furnishings + Fixtures			
254.1	Safety Equipment	0	7	14
254.2	Chemical Lab Shop	1003	206	13
254.3	Office Equipment + Furnishings	120	3	0
254.4	Change Room Equipment	140	30	3
254.5	Environment Monitoring Equipment	648	352	31
254.6	Dining Facilities	176	27	2
	Subtotal	2088	625	63
255	Waste Water Treatment Equipment	1615	1811	0
26	Main Cond. Heat Reject System			
261	Structures			
261.1	Make-up Water Pretreatment Bldg.	8	563	292
261.2	Circulating Water Pump House	94	1494	441
261.3	Make-up Water Pretreatment Bldg.	63	821	562
261.4	Cooling Tower Sewerage Bldg.	94	192	73
	Subtotal	260	3070	1368

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
262	Mechanical Equipment			
261.1	Heat Rejection System	21781	18776	2275
	Subtotal	21781	18776	2275
91	Construction Services			
911	Temporary Construction Factory			
911.1	Temporary Buildings	0	50272	5186
911.2	Temporary Facilities	0	106698	23535
	Subtotal	0	156970	28721
912	Construction Tools and Equipment			
912.1	Major Equipment	0	7849	36898
912.2	Miscellaneous Vehicles	0	0	0
912.3	Purchase of Small Tools	0	894	9973
912.4	Expendable Supplies	0	0	14959
912.5	Safety Equipment and Inspection	0	778	898
	Subtotal	0	9520	62727
913	Payroll Insurance and Taxes			
913.1	Social Security Tax	0	0	0
913.2	State + Federal Unemployment	0	0	0
913.3	Workmens Compensation Insurance			
913.4	P.L. + P.D. Insurance	0	0	0
	Subtotal	0	0	0
914	Permits, Insurance and Local Taxes			
914.1	Builders All Risk Insurance	0	0	2039
914.2	Fees and Permits	0	0	0
914.3	State and Local Sales Taxes	0	0	0
914.4	Nuclear Liability Insurance	0	0	2039
915	Transportation	0	0	0

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
92	Home Office Engineering and Service			
921	Home Office Services			
921.1	Salaries	125178	0	0
921.2	Expenses - % of Salaries	32046	0	0
921.3	Direct Payroll Expenses	38054	0	0
921.4	Overhead Loading	90128	0	0
921.5	Outside Consultants Services	0	0	0
921.6	Fee for Home/Office Services	25036	0	0
	Subtotal	310442	0	0
922	Home Office Q/A			
922.1	Salaries	4506	0	0
922.2	Direct Payroll Expenses	1352	0	0
922.3	Overhead Loading	3220	0	0
922.4	Expenses	1337	0	0
	Subtotal	10415	0	0
923	Home Office Construction Management			
923.1	Salaries	2103	0	0
923.2	Direct Payroll Expenses	631	0	0
923.3	Overhead Loading	1502	0	0
923.4	Expenses - % of Salaries	621	0	0
	Subtotal	4857	0	0
93	Field Office Engineering and Service			
931	Field Office Expenses			
931.1	Office Furniture & Equipment	0	441	5784
931.2	Telephone and Communications	0	232	2294
931.3	Office Supplies	0	0	7479
931.4	First Aid and Medical Expense	0	697	100
	Subtotal	0	1371	15657

TABLE C.2 (Cont'd)

Account No.	Account Title	Overnight Costs (\$000 1983)		
		Factory Equipment	Site Labor	Site Materials
932	Field Job Supervision			
932.1	Salaries	170142	0	0
932.2	Salaries	0	0	0
932.3	Direct Payroll Expenses	49871	0	0
932.4	Overhead Loading	32346	0	0
932.5	Relocation Expense-Allowance	16724	0	0
932.6	Fee for Construction Services	24885	0	0
932.7	Survey Engineers (Manual)	0	12312	0
	Subtotal	293968	12312	0
933	Field QA/QC			
933.1	Salaries	11016	0	0
933.2	Direct Payroll Expenses	3305	0	0
933.3	Overhead Loading	2153	0	0
933.4	Expenses	2804	0	0
933.5	Construction Training Meeting (Crft)	0	6853	0
	Subtotal	19277	6853	0
934	Plant Startup & Test			
934.1	Salaries	7210	0	0
934.2	Direct Payroll Expenses	2163	0	0
934.3	Overhead Loading	5147	0	0
934.4	Expenses - % of Salaries	1001	0	0
	Subtotal	15522	0	0

APPENDIX D:
NORMALIZED REGIONAL LABOR AND MATERIALS COST INDICES

APPENDIX D:
NORMALIZED REGIONAL LABOR AND MATERIALS COST INDICES

Zone	City	Concrete		Mechanical		Electrical	
		Material	Labor	Material	Labor	Material	Labor
NE	Boston	1.05	1.03	1.02	1.06	0.95	1.06
NE	Baltimore	1.06	0.80	0.99	0.90	0.96	0.90
NE	New York	1.22	1.07	0.90	1.20	0.97	1.15
NE	Philadelphia	0.88	0.99	0.98	1.08	0.96	1.04
NE	Pittsburgh	0.91	1.02	0.96	0.99	0.94	0.88
NE	Buffalo	1.10	0.97	0.98	1.01	1.00	1.03
Normal Average		1.00	0.98	1.00	1.00	0.96	1.01
SE	Atlanta	0.83	0.77	0.99	0.809	0.92	0.78
SE	Jacksonville	0.92	0.80	0.98	0.80	0.96	0.73
SE	Louisville	0.94	0.92	0.99	0.93	0.92	0.88
SE	Charlotte	0.93	0.80	0.95	0.66	0.94	0.64
Normal Average		0.88	0.82	0.99	0.77	0.94	0.76
UMW	Minneapolis	0.87	0.91	0.99	1.00	0.96	1.00
UMW	Chicago	0.97	0.95	1.05	0.96	0.97	0.94
UMW	Kansas City	0.90	0.98	0.99	0.94	1.00	0.97
UMW	Detroit	0.89	0.97	1.00	1.02	1.04	0.97
Normal Average		0.88	0.93	1.00	0.95	0.99	0.97
LMW	Houston	1.08	0.82	0.97	0.96	0.94	0.94
LMW	Dallas	0.92	0.89	0.96	0.89	0.96	0.85
LMW	Jackson	0.96	0.77	0.98	0.75	0.92	0.71
LMW	Memphis	0.91	0.79	0.97	0.88	0.93	0.86
Normal Average		0.94	0.82	0.98	0.85	0.94	0.84

Zone	City	Concrete		Mechanical		Electrical	
		Material	Labor	Material	Labor	Material	Labor
NW	Salt Lake	0.99	0.88	1.02	0.95	0.99	0.92
NW	Seattle	0.94	1.00	0.98	1.13	0.99	1.16
NW	San Francisco	1.11	1.14	0.98	1.61	1.07	1.42
NW	Portland	1.09	0.99	0.96	1.15	1.00	1.11
Normal Average		1.00	1.00	1.00	1.17	1.01	1.15
SW	Los Angeles	0.86	1.10	0.98	1.24	0.96	1.24
SW	Denver	1.15	0.91	0.92	0.96	0.96	0.98
SW	Albuquerque	1.05	0.87	0.98	0.83	0.91	0.79
SW	Phoenix	1.09	0.86	0.98	1.08	1.00	0.83
Normal Average		1.01	0.93	0.99	0.99	0.96	0.96
National Average		0.95	0.91	0.99	0.95	0.97	0.95

Notes: Normalized to the Middletown location of the EEDB reference plants.
Adapted from material presented in: Means - Building Construction Cost Data -
1985, 43rd Ed., R.S. Means (1985).

NRC FORM 335 (2 84) NRCM 1102, 3201, 3202		U.S. NUCLEAR REGULATORY COMMISSION		1 REPORT NUMBER (Assigned by TIDC add Vol No, if any) NUREG/CR-4568 ANL/EES-TM-297					
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SEE INSTRUCTIONS ON THE REVERSE									
2 TITLE AND SUBTITLE A Handbook for Quick Cost Estimates: A Method for Developing Quick Approximate Estimates of Costs for Generic Actions for Nuclear Power Plants				3 LEAVE BLANK					
5 AUTHOR(S) J. R. Ball				4 DATE REPORT COMPLETED <table border="1"> <tr> <td>MONTH</td> <td>YEAR</td> </tr> <tr> <td>March</td> <td>1986</td> </tr> </table>		MONTH	YEAR	March	1986
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7 PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Argonne National Laboratory 9700 South Cass Avenue Argonne, Illinois 60439				6 DATE REPORT ISSUED <table border="1"> <tr> <td>MONTH</td> <td>YEAR</td> </tr> <tr> <td>April</td> <td>1986</td> </tr> </table>		MONTH	YEAR	April	1986
MONTH	YEAR								
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10 SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Division of Safety Review and Oversight Office of Nuclear Reactor Regulation U.S. Nuclear Regulatory Commission Washington, DC 20555				8 PROJECT/TASK/WORK UNIT NUMBER 9 FIN OR GRANT NUMBER FIN A-2316					
12 SUPPLEMENTARY NOTES				11a TYPE OF REPORT Technical (Final)					
13 ABSTRACT (200 words or less) This document provides guidance for developing "quick" approximate estimates of the cost of implementing generic regulatory requirements for nuclear power plants. A method is presented for relating the known construction costs for new nuclear power plants (as contained in the Energy Economic Data Base) to the cost of performing similar work, on a back-fit basis, at existing plants. Cost factors are presented to account for variations in such important cost areas as construction labor productivity, engineering and quality assurance, replacement energy, reworking of existing features, and regional variations in the cost of materials and labor. Other cost categories addressed in this handbook include those for changes in plant operating personnel and plant documents, licensee costs, NRC costs, and costs for other government agencies. Data sheets, worksheets, and appropriate cost algorithms are included to guide the user through preparation of rough estimates. A sample estimate is prepared using the method and the estimating tools provided. This document is a stand-alone supplement to NUREG/CR-3971, "A Handbook for Cost Estimating."				b PERIOD COVERED (Inclusive dates)					
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